NATURE

No. 4508 SATURDAY, MARCH 24, 1956 Vol. 177

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RESEARCH AND DEVELOPMENT IN THE ELECTRICITY SUPPLY INDUSTRY

THE Departmental Committee appointed by the Minister of Fuel and Power in July 1954, under the chairmanship of Sir Edwin Herbert, "to inquire into the organization and efficiency of the electricity supply industry in England and Wales in the light of its working under the Electricity Act, 1947, and to make recommendations"*, had wider terms of reference than that which, under Sir Alexander Fleck's chairmanship, reported last year on the organization of the National Coal Board. Indeed, it is the first comprehensive review of the working of a nationalized industry in Britain and, though its main recommendations are concerned with organization, the report also embraces matters relating to staff, finance, tariffs, research and development, as well as to the powers and duties of the Minister. The Committee approached its task with the sole object in mind of the improvement and welfare of this great industry, and its recommendations are intended to make the nationalized industry work better within the framework of public ownership. None the less, the report is a challenge to constructive thinking, not merely about the electricity supply industry in Britain, but also about the limitations and implications of nationalized industry in general. An important feature is its attempt to lay down criteria by which the efficiency of such an industry can be judged.

The report is thus of no less scientific interest than the Fleck report, for, while there is much common ground in the two reports, the whole approach of the Committee is in welcome contrast to the political prejudice which has bedevilled so much discussion of nationalization, both as regards its application to particular industries and the question of public accountability. The Herbert Committee does not indeed suggest easy criteria; but it does indicate factors, if not principles, which should guide decisions on both issues and which cannot wisely be ignored. It notes, for example, how impossible it is to avoid some political element in the whole structure of the industry, including the price structure of its product, because the amount of capital to be raised depends not upon the attractive power of the industry so much as upon the Government's decision as to how much capital shall be raised on the national credit on its behalf. While there is nothing in the Act which requires the industry to supply electricity on uncommercial terms to any customer or class of customer, or to conduct itself in such a way that it would have to face higher costs than a private business, the Committee considers that the industry is in the same position as any other undertaking borrowing money through the mechanism of the market, provided it sees that the Treasury guarantee is not called upon. The Committee accepts the need for a considerable degree of 'public accountability' in a nationalized industry, but suggests that there is some confusion of thought as to how far this extends to borrowed money.

The Committee approached its task by asking itself five questions. Is the industry making the best use of its man-power and physical resources? Is it making the best use of the capital it raises and the revenue it earns? Are the consumers being properly charged for the services rendered to them? Is the organization of the industry well adapted for securing the best use of capital, man-power and physical assets and for ensuring that proper charges are made to consumers? Is the organization well adapted and the staff sufficiently capable to secure the same ends in future?

The report begins by recording admiration for the zeal shown at all levels of the industry since vesting day. In the opinion of the Committee, the way in which the task of carrying out the amalgamations required was achieved with no friction so far as consumers were concerned, and a minimum of internal friction, reflects great credit on all concerned both in planning and execution. Since vesting day, in face of shortages of capital, man-power and physical assets, the industry has largely overcome the shortage of generating plant, and has gone far towards making good the war arrears of maintenance and reinforcement of distribution systems. It has made substantial technical advances and, at a time when coal has increased in price by 270 per cent and the general cost of living index by 137 per cent, is supplying electricity to consufners at an average price only 30 per cent above that ruling in 1939.

The main question with which the Committee has been concerned is not, however, whether the organization of the industry has served its purpose well in the period since vesting day, but whether it is the best form of organization for the running and development of the industry in the future, now that the initial reorganization has been effected. In particular, since the industry has lost the classical spur to efficiency—the possibility of failure or at least of showing up badly by comparison with others—the Committee was concerned as to whether the forms of control used in the industry are effective in securing that money is not spent on unnecessary projects and that full value for money is obtained out of expenditure on necessary projects. The Committee thinks it is necessary to retain a central authority, but that it is essential to remove from such authority both the executive responsibility for generation and transmission and the present vague general responsibility for the industry as a whole, and also to define clearly the functions to be retained at the centre.

Again, the Committee believes that the industry has a long way to go in the introduction of modern aids to good management. In budgeting, in work-study, in operational research, in incentive wage systems, it is not in the van, and in some respects is

* Report of the Committee of Inquiry into the Electricity Supply Industry. (Cmd. 9672.) Pp. viii+189. (London: H.M. Stationery Office, 1956.) 6s. 6d. net.

lagging, partly because it has been unwilling to face the problem of staff redundancy. The industry must also take very energetic steps to ensure that it attracts and retains an adequate supply of first-rate talent for both technical and managerial posts. Like the Fleck Committee, the Herbert Committee points out that part of the trouble lies in the low level of salaries at the top and in the limited number of independent commands. The advent of nuclear power offers the industry an opportunity of seizing once more the imagination of the young, recruiting talent, grooming it for responsibility, and giving it its head.

These criticisms of structure, delegation, management aids and recruitment are all interlinked; but the very size of the industry and the remoteness of authority tend to lead to loss of morale unless it is built up by positive measures. The Committee rightly observes that the industry requires men as close to the field as possible, technically capable, and leaders with initiative and courage. It requires great names in the future as in the past—great engineers, managers and administrators; and it is clear enough that in the minds of the Herbert Committee the scientists and technologists can be expected to provide such names right at the top.

Beyond these criticisms, the Committee recommends that the Central Electricity Authority should be reconstituted, its responsibility for generation, including the construction and operation of the power stations, grid and super-grid being transferred to a new statutory central electricity generation board. The Authority would then be required, *inter alia*, to approve the general plans of both the generating board and the area boards and any proposal by an area board to construct a generating station, as well as to approve research arrangements and programmes. Its independent powers of scrutiny would place the Authority in a strong position to insist upon proper operational research and work-study and to encourage more attention to utilization research. The Committee visualizes the Authority as a body of men, independent of the boards and their day-to-day actions, but ready to help, to co-ordinate and to stimulate, and providing the Minister with an independent body of expert opinion within the industry capable of the critical scrutiny of finance and development which is now lacking.

One consequence of the passive attitude to redundancy adopted by the present Central Electricity Authority has been that work-study, operational research and investigations into restrictive practices are undertaken by management at all levels without enthusiasm—if they are pursued at all—and the most effective deployment of man-power is never possible. In the context of the development of nuclear power in the coming decades, this would clearly be fatal to efficiency. The nation can only afford the large investment of resources which nuclear power development requires if it is assured of the full benefits not only in the saving of fuel but also of man-power which nuclear energy permits. In urging the industry to adopt a more flexible and realistic attitude towards redundancy, the Committee understates the case when it observes that the national economy may well be damaged if men who are in short supply and may be badly needed elsewhere are retained by an industry which cannot itself fully employ them.

It is a marked feature of this report that such tendencies are kept carefully in mind, and the Committee's recommendations are framed to encourage the necessary flexibility and adaptability. This is noticeably true in its comments on the recruitment and promotion of staff. It has already been noted that the industry needs to face more realistically the problems which changing needs for different grades of man-power arising out of improvements in technique and organization may create from time to time; though curiously enough the Committee does not make the obvious comment that technical education and adequate training after entering the industry could do much to ease such problems, and foster the adaptability which is so important in an era of rapid technological change. Its preoccupation is rather that the industry should make the fullest possible use of the opportunity provided by the construction and operation of nuclear power stations to attract the best type of recruits for its technical and managerial posts. It looks at the industry rather through the eyes of a keen, intelligent, young man with a good engineering degree.

First, it recommends that the industry should urgently review the conditions which are causing well-qualified men of the calibre of potential leaders to turn to other fields, and that it should improve the terms of service, including starting salaries and differentials for graduate trainees. Next, it is disturbed by the attitude of the Central Authority towards the advancement of graduate trainees and its policy on training potential managers of the first rank. Here it recommends a deliberate system of selective training and posting of able young men, so that potential leaders may prove their qualities in successive posts and gain the experience which will fit them for higher management. It challenges the Authority's confidence that under the present arrangements future leaders will automatically be forthcoming, and it would like to see more extensive cross-posting of promising young men between the generation and transmission and distribution sides of the industry.

Like the Fleck Committee, the Herbert Committee attaches great importance to a deliberate policy in this matter; and the recommendations are broadly similar, as they are again in regard to research and development. This is discussed under two headings. First, of utilization research, the Committee challenges the adequacy of the allocation of only 5 per cent of the Central Authority's budget for research on utilization research, and recommends that facilities for this purpose be strengthened and provided with more resources. Because this work may not have such high scientific interest as other parts of the research programme, it is suggested that it has not been adequately supported.

The Committee is also critical of both the scale and organization of research and development within the industry. In 1954–55 expenditure for this purpose

was about £700,000, or less than 0·2 per cent of the industry's annual revenue; and the Committee suggests that the industry is relying too largely for technical development and progress on research organizations outside the industry. The expenditure on research includes, in fact, an allocation of £60,000 a year for research in universities and technical colleges and more than £250,000 to co-operating research organizations, chiefly to the British Electrical and Allied Industries Research Association. Estimated expenditure on research for 1955–56 is given as £625,000 at the Authority's headquarters and £850,000 by the divisions or area boards and £270,146 to research associations (including £100,000 to the National Industrial Fuel Efficiency Service).

To determine how far the Committee's criticisms of the scale of research are sound requires a much closer examination than is given in this report, and at least some indication of the lines along which investigations are more profitably pursued within the industry rather than outside, and of the type of problem that is being neglected. The comment that an industry that has to have scientific knowledge pushed at it is never as strong as the industry which is organized to pull it in is fair enough; and the Herbert Committee appears to be disturbed rather with the present attitude to research and with the possibility that the present scale of research does not supply the industry with sufficient men inside scanning the horizon of knowledge and capable of interpreting what they see for its guidance. The Committee is also disturbed at the diffusion of responsibilities for research and development inside the Authority.

The Committee believes that the responsibilities of the Electricity Supply Research Council are much more limited than the Council's terms of reference indicate, and that the present organization established to deal with research and development is inadequate if science is to be put to work and bear fruit in this industry. It urges that in such a technical industry science should be represented at the highest level of management and that, with the exception of utilization research, a full-time member of the proposed generation board should be responsible for research and development, supported by a research staff of high quality. It believes that the area boards should also extend their research activities and be less dependent on the initiative of the electrical manufacturing industry for technical progress and innovations.

There can be no question that the Herbert Committee is right in holding that the electricity supply industry in Britain, by its very nature, should be in the forefront of industries organizing and applying research and development on an extensive scale; and its observations in regard to fuel requirements and nuclear energy indicate one direction in which expansion of that effort is required. It is better, the Committee suggests, for the Authority to build and operate a limited number of nuclear power stations than to wait on developments instituted by other authorities and organizations at home or overseas; and its criticism of the organization being established by the Authority to deal with its nuclear responsibilities reflects this concern. The recommendation that the post of deputy chief engineer, responsible for the construction, operation and development of nuclear stations, be created is reasonable; though there may be need for more attention to what is already being done in the way of research and development by the Atomic Energy Authority than is indicated in this report, bearing in mind the Committee's remark as to the desirability of the Central Electricity Authority being able to meet the Atomic Energy Authority and the manufacturing consortiums at scientific and technological levels on equal terms.

The Herbert report thus goes far to supply the efficiency audit which has often been adumbrated in discussions on the control of nationalized industries and their public accountability; and it is an important contribution to that debate. It indicates factors which are not peculiar to the electricity supply industry, but are valid in respect of accountability or efficiency of any such industry, such as the bearing on efficiency of opening every transaction to public examination and the repercussions of a monopoly, with the absence of alternative employment, on conditions of service and recruitment. Warm appreciation of the achievements of the industry has not prevented frank appraisal of its inherent dangers—and those dangers are not limited to this particular nationalized industry.

The report is also a valuable stimulus to constructive thought about the factors upon which technological progress depends. Even where the Committee's conclusions are accepted with reserve, they indicate none the less the importance of those factors for technical efficiency. No scientist or technologist could wish for a clearer and fairer statement as to the place of research and development in industry, or of the importance of a considered policy for the recruitment and promotion of staff. The need for flexibility and adaptability, for open-mindedness and ability to face the future and to consider the implications of technical change and advance, not merely in terms of finance and economics, but equally in relation to staff and society as a whole, are emphasized at every turn; and they are seen against the background of the nation's limitations in man-power and other resources. There is no shirking of difficult or unpleasant issues; and although the report says relatively little about technical education and the relation of the research organization of the electrical supply industry to that of Britain as a whole, it none the less makes it abundantly plain that any realistic appraisal of expenditure on research must take full account of what is being done by nationalized industries such as this, and of their relations with the Department of Scientific and Industrial Research and the research associations. Last but not least, the report supplies further evidence of the vital importance of an adequate system of education (technical and technological as well as general), if industry is to be supplied with the technicians and general operatives, as well as with scientists and technologists, possessing the adaptability which is so essential in an era of rapid technological development.

RALEIGH'S ATTEMPTED COLONIZATION OF VIRGINIA

The Roanoke Voyages 1584–1590

Documents to illustrate the English voyages to North America under the Patent granted to Walter Raleigh in 1584. Edited by Prof. David Beers Quinn. Vol. 1: pp. xxxv+496. Vol. 2: pp. vi+497–1004. (Works issued by the Hakluyt Society. Second Series, No. 104.) (London: Cambridge University Press, 1955.) 120*s*. net.

IN these two most valuable and fascinating volumes Prof. D. B. Quinn has continued for the colonization of Virginia under Raleigh what he had earlier completed for Sir Humphrey Gilbert's ventures in New England and Newfoundland. Spain, through Columbus, discovered the Caribbean lands, and within fifty years or so her empire stretched from California to Tierra del Fuego. Portugal, using Vespucci, coasted Brazil and Argentina and began its colonization in earnest by 1550. But England, which through John Cabot had explored from Greenland to New England, made no attempt to establish a colony in the New World. The Tudor monarchs sensed, almost immediately, that such voyages westward would not lead easily to Cathay and the Spice Islands, and so, apart from the fisheries of Newfoundland, English interest in the Americas lapsed until 1578. Gilbert's warrant to establish colonies in North America lasted from 1578 until 1584, and thereafter Sir Walter Raleigh obtained the Queen's patent to do so, provided he did not interfere with the Newfoundland fisheries.

Hakluyt published many of the main sources for the voyages and colonization of Virginia undertaken between 1584 and 1590. The documents in these two volumes include those of Hakluyt supplemented by many minor documents and new material and interpretations derived from modern scholarship. Vol. 1 includes seventy-three documents dealing with the 1585 and 1586 voyages, while Vol. 2 has thirty-four English documents on the 1587–90 voyages, together with fifty-two Spanish documents, two of them published originally by Miss Wright, which deal with these English voyages to Roanoke Island in Virginia.

The introduction, of seventy-six pages, assesses the material, and at the beginning of each chapter a narrative is given of the events and material in the documents. Footnotes and annotations are most liberal and reveal the thorough and rich scholarship of the editing. Prof. Quinn considers that during 1584–86 the English ventures were not over-publicized, probably because of the danger of Spanish interference. From 1587 onwards, relations with Spain were open war if not official war, and after the defeat of the Armada there was no further fear of Spain. The documents published by Hakluyt were in the nature of propaganda for the colony, and Quinn believes that they suppressed some features of the expeditions to present the project in as attractive a light as possible. He also considers there is evidence to show that Raleigh and Grenville intended to establish a colony at about 36° N., which would be sufficiently north of Florida to avoid Spanish attack yet close enough to the West Indies to provide a base for privateering. It is this potential role of the Virginia colony on Roanoke which led the Spaniards to keep on searching to destroy it from 1590 until 1600, unaware that it had been abandoned in 1590.

The 1584 voyage located Roanoke Island, while Grenville's voyage of 1585 established a fort and colony on it. Lane was left with a garrison, expecting Raleigh to send a relief ship and stores by Easter 1586. It did not come until late June, and by then Lane and the colonists had been taken off by Drake, at their request. Grenville arrived with three hundred men two weeks later to strengthen the colony, but finding it deserted he left a holding party of only eighteen men, who were attacked by Indians and overcome. By such a narrow margin did the fair enterprise of Raleigh's colonization of Virginia fail to succeed: as Quinn notes, "the whole sequence of colonization was destroyed, inadvertently, by Drake". The drawings by White and the maps by White and Hariot, no less than their accurate descriptions of the Indians and the flora and fauna, are historical documents of unique value. There are appendixes on the map of Virginia as it was explored in these expeditions, on Indian words and on the archæology of the settlements. By 1950 the fort made in 1585 on Roanoke was completely reconstructed by Harrington. Sources and indexes of subjects, names and places complete a most comprehensive and brilliant study of this early venture in the origins of the British Empire. Prof. Quinn and the Hakluyt Society are to be warmly congratulated on this absorbing and scholarly addition to their famous series.

ARTHUR DAVIES

LUCUBRATORY BIOCHEMISTRY

Biochemistry

An Introductory Textbook. By Prof. Felix Haurowitz. Pp. xvi+485. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 54*s*. net.

ACCORDING to the author, this text-book "is designed to form the basis of a one-semester course in biological chemistry intended for seniors and graduate students majoring in bacteriology, botany, chemistry, physiology, or zoology". After an introductory chapter, in which the development and scope of biochemistry, the fundamentals and special fields of the subject, and the literature, are all discussed, chapters are devoted to water and its functions, the mechanism of biochemical reactions, the chemistry and metabolism of carbohydrates, proteins and lipids, nucleic acids, porphyrins, mineral metabolism, enzymes, energy balances and nutrition, and human biochemistry. The balance of the book is different from the sort of volume that is produced for medical students, and includes both structural and dynamic aspects of the subject. It incorporates material on animal, plant and bacterial biochemistry.

Since the book is meant for seniors and graduate students it would seem all the more important that it should be accurate in detail, with an adequate discussion of the evidence on which the accepted ideas about metabolic processes are based. To produce a book for graduate students in a subject which is developing as rapidly as biochemistry advances to-day is a problem to be faced by all careful writers with some alarm and with intense care for detail and form. Dr. Haurowitz's book reveals little evidence of his awareness of these needs. Although the book is meant for seniors, references to original publications are not given in most instances. Such references as are included are largely to books and to review

articles. One would hope that the senior student would have the time and stimulus to read at least a few original papers. In a number of instances Dr. Haurowitz includes a reference to a publication appearing in 1955 without documentation. For example, the section on p. 240 dealing with "Acetalphospholipids" includes the undocumented reference, "Klenk, 1955". One reader of this paragraph at any rate is left with complete bewilderment as to what Dr. Haurowitz means to say, and if indeed he intended to give an account of Klenk's interesting findings published in *Hoppe-Seyler's Zeitschrift* (**299**, 66–73; 1955) about acetalphospholipids and plasmalogens, he could have done so quite easily. References are also made in a number of cases to the possible role of hydride ions ($H:^-$) in the reduction of certain coenzymes; but no references to the literature are given. On p. 386 the reader is told that as the result of studies with deuterium there is evidence that diphosphopyridinenucleotide and triphosphopyridinenucleotide accept hydrogen directly from substrates, and that if protons were transferred they would suffer exchange with the hydrogen ions of the solvent, a possibility ruled out on experimental evidence. Yet in numerous places the transfer is depicted as involving protons together with electrons, and occasional references are made to hydride ions. The discussion on p. 387 of the mechanism of action of alcohol dehydrogenase and acetaldehyde dehydrogenase is likely to confuse any critical student.

The text contains many misstatements, contradictions and unjustified generalizations, of which some will be quoted. On p. 42 we are told that "the compounds containing high-energy phosphate bonds are *unstable substances* [author's italics] readily hydrolyzed by water". According to p. 55, "transacetylase" and "acetokinase" are different names for the same enzyme. But this is not the enzyme for which the name "actokinase" was introduced by Ochoa and his colleagues (*J. Biol. Chem.*, **211**, 737; 1954). On p. 64 occurs the interesting statement, "Natural isotopes are stable. . . . In contrast to the radioactive isotopes the natural isotopes are stable and do not emit damaging radiation. However, their determination requires a mass spectrometer which is an extremely expensive piece of equipment". Has Dr. Haurowitz never heard of naturally occurring radioactive isotopes, for example of potassium or of carbon? From p. 78 we learn that "like all substances with asymmetric carbon atoms, the sugars are optically active". The intelligent student who has already learned about internal compensation will be puzzled by this. On p. 124 under the heading "Ketogenesis" occurs the following statement: "If carbohydrates are withdrawn from the food of diabetic patients, both hyperglycæmia as well as glycosuria disappear. However, another serious disturbance arises due to the formation of large amounts of acetoacetic acid $CH_3—CO—CH_2—COOH$, β-hydroxybutyric acid $CH_3—CHOH—CH_2—COOH$, and acetone $CH_3—CO—CH_3$. . . . Clearly, the diabetic patient oscillates between the two dangerous symptoms of glycosuria on the one hand and acidosis on the other. Both are relieved by insulin". Physicians who at one time treated diabetes by the administration of a diet rich in fat and who reduced diabetic ketosis by undernutrition or starvation would be most interested in this passage. On p. 132 the statement is made, "The amino acids are colorless substances that are soluble in water", although later the insolubility of cystine in water is mentioned (p. 156). According to p. 154, "Since arginine is formed from ornithine and ornithine from glutamic acid through its semialdehyde (see p. 150), arginine synthesis is a slow reaction which sometimes is not rapid enough to provide for the arginine requirements of the organism. Arginine is, therefore, one of the amino acids which are nonessential for some animals such as dogs, but essential for others such as chicks". That any modern biochemist should accept the validity of this sort of argument is astonishing. On p. 155 we are told: "In the muscle of invertebrates, which is free of creatine phosphate, its role of phosphate donor is taken over by arginine phosphate". Any generalization of this sort is dangerous in view of the existence of some invertebrates in which both creatine phosphate and another phosphagen are found (Baldwin, "An Introduction to Comparative Biochemistry", p. 74; Cambridge University Press, 1948; Baldwin and Yudkin, *Proc. Roy. Soc.*, B, **136**, 614; 1950). P. 273 carries the following statement: "The low concentration of the hormones in the sex glands was primarily responsible for the failure of previous workers to isolate the hormones from the glands. Evidently the hormones are rapidly excreted into the urine. Urine, in contrast to the organs, contains only small amounts of other lipids; therefore the urinary benzene extract contains relatively uncontaminated hormones". After this astonishing dictum the incorrect numbering of the sterol skeleton on p. 265 seems to matter less. On p. 279 the formulæ for corticosterone and other adrenal steroids are also incorrect. On p. 276 we are told that "Attempts to prepare estrogenic hormones synthetically, led to the unexpected result that certain *stilbene derivatives*, [author's italics] such as dihydroxydiethylstilbene, are just as active as estradiol". That is historically incorrect, as can be seen by consulting the early papers of Dodds and his collaborators. Likewise, the statement on p. 277, that one of the simplest substances with estrogenic activity is 4-hydroxyphenylpropene, is wrong (see, for example, Lawson, *J. Chem. Soc.*, 4696; 1954). On p. 287, the following two sentences appear not far apart: "The high surface activity of soaps and of proteins is responsible for their ability to form foams". "The surface activity of the octyl alcohol molecules is much higher than that of proteins so that they displace the proteins from the water surface and the formation of the froth is prevented". A paradox indeed! On p. 415 occurs the statement, "Owing to their insolubility in water and in the digestive juices, fats and oils are more slowly digested than carbohydrates and proteins. For this reason, fats are not the most efficient source of energy, although they can be used for this purpose as mentioned in the preceding paragraph". What does this mean? Examples of this sort could be added to considerably; but enough has been said to indicate the general flavour of the book and of the writing it contains.

The balance of the book is unusual. A very large amount of space is devoted to the chemistry and physical chemistry of proteins, and a picture of a Langmuir film balance is included on p. 287. The statement about the tricarboxylic acid cycle on pp. 59–61 is a category of the reactions involved, with the promise that details of the cycle and the chemical nature of its members "will be discussed later (pp. 249 and 119)". Unfortunately, we are nowhere given a discussion of the evidence from which the existence of the cycle and other metabolic pathways have been

deduced by Szent-Györgyi, Krebs, Ochoa and many others, and this surely could have been included at the expense of some of the space devoted, for example, to alkaloids (pp. 177–180) or to terpenes (pp. 255–257).

A critical and accurate text-book of biochemistry for postgraduate students is needed which is not written with a medical point of view in mind and which includes both dynamic and static aspects of the subject within a reasonable size. Dr. Haurowitz has had the courage and tenacity of purpose to attempt this important task, and the 485 pages of his book might have provided such a volume. Unfortunately, they have failed to do so.

F. G. Young

NORTH-AMERICAN PLANT TAXONOMY

An Introduction to Plant Taxonomy

By George H. M. Lawrence. Pp. viii+179. (New York and London: The Macmillan Company, 1955.) 23*s*. net.

THIS little book consists largely of a somewhat curious selection of material from "The Taxonomy of Vascular Plants" by the same author. According to the preface, it "is intended to serve as an aid to the non-taxonomist in the use of a manual or flora that accounts for the plants of any region of North America". A brief introductory chapter explains the nature and significance of taxonomy and distinguishes clearly between classification and nomenclature, two things which are frequently confused by the beginner. The survey of systems of classification, which occupies a dozen pages, seems of rather doubtful value to the non-taxonomist who simply wishes to use a flora. Engler's system is criticized once again for its lack of phylogenetic truth, in spite of the fact that it is admittedly based on artificial grades of perianth complexity and that its author never claimed any phylogenetic significance for it.

Nearly one-third of the book is occupied by what is in effect an elaborate illustrated glossary of the terms which may be used in describing vascular cryptogams and seed plants. The illustrations, though generally clear and helpful, are not uniformly accurate; for example, the fern sporangium (Fig. 8*f*) is shown with a stalk which bears no resemblance to reality. A more important point, however, is the great number of terms which are defined. These alone seem enough to discourage any non-taxonomist from attempting to use a flora, and many of them, in my opinion, are unnecessary words which, anyhow, are very rarely met with in modern works. The tendency nowadays is to reduce the number of terms used in description, even if it means a slight loss of precision or the substitution of a rather longer phrase in plain English. The greater precision which might be supposed to be obtained by using a word such as velutinous is largely illusory. The non-taxonomist will neither remember nor bother to look up afresh the precise meaning of such words, while specialists frequently differ over the exact application of the multitudinous terms used to describe qualitative features.

As long as botany consisted essentially of the systematics of flowering plants, this great abundance of descriptive words was all part of the game, but this period in the development of the science ended more than half a century ago. Taxonomists to-day need to make their work readily available to ecologists, physiologists and indeed to every kind of botanist, as well as to the host of happy amateurs. It is high time that many of these esoteric words were forgotten. It seems, therefore, regrettable that thirty-nine words describing hairiness and no fewer than sixty-two describing the shapes of leaves or parts of leaves are defined.

It is difficult to see how the summary of the International Code of Nomenclature or the brief account of phylogeny and biosystematics can help the kind of reader referred to in the preface, though the few pages dealing with collecting and identifying may well be of value to the beginner, and the chapter on taxonomy in North America is of interest to the historically minded.

The remainder of the book deals with important families (of flowering plants) in a rather chatty way. The same kind of information is to be found in more detail and more concisely expressed in most floras. Finally, it is perhaps worth pointing out that the cost per page seems to be about twice as much as that of comparable books printed in Britain.

T. G. Tutin

NEWER TECHNIQUES IN ORGANIC ANALYSIS

Organic Analysis

Edited by John Mitchell, Jr., I. M. Kolthoff, E. S. Proskauer and A. Weissberger. Volume 2. Pp. viii+372. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1954.) 8.50 dollars.

THE first volume of this work presented methods for the quantitative determination of a number of organic functional groups. The opening chapters of this second volume describe further specific determinations of the carboxyl group, the ester group, the nitro, nitroso and nitrate groups and of total nitrogen by the standard methods. The fourth chapter deals with the uses of lithium aluminium hydride in analysis. One application is to the determination of active hydrogen, and this provides an alternative to the Zerewitnoff method. Lithium aluminium hydride is so powerful as a reducing agent that its action upon various oxygen-containing groups is non-selective. However, the amount of the reagent consumed is proportional to the oxygen present in the groups attacked, and a method has been developed, using an indicator such as N-phenyl-aminoazobenzene, which gives a direct titration of the number of oxygen atoms present in a compound (ether oxygens being excepted). Great care is necessary to exclude moisture, oxygen and carbon dioxide; but the method should be very valuable.

The remaining five chapters of the book are concerned with special techniques. An account of coulometric methods does not open up many possibilities of their use in organic work. A chapter on polarography shows in detail the many pitfalls and difficulties which may arise with organic substances. Polarographic methods are rapid and convenient in certain instances, but great care and attention to detail are essential. A discussion of methods based

on reaction-rate is of considerable interest, but their applicability would seem to be rather restricted. The most important field is probably that of enzyme and microbiological reactions, in which recent development has been rapid, but in this direction the account is disappointing.

A chapter entitled "Phase Solubility Analysis" deals with tests for purity and the determination of impurities by precise solubility measurements. These methods are sound in principle, but are often very time-consuming. They have proved particularly valuable in the examination of some biological products where the criterion of melting-point is not available. The concluding section on "Counter-current Distribution" is concerned with a method of highly organized multiple-solvent extraction. Convenient devices for carrying out many successive partitions systematically are described, and the theory of the fate of solutes present is worked out in detail. This technique has been developed largely by Dr. L. C. Craig and has been applied to the separation of acids, fats, bile constituents and protein degradation products.

The articles in this volume have been written by experts and they are in general well documented. It is not a serious disadvantage that some of the methods discussed have a restricted field of application. The production of the book is excellent, and the two volumes taken together will be of real value to the practical organic chemist. G. M. BENNETT

BIRDS OF THE KATHIAWAR PENINSULA, INDIA

Birds of Saurashtra—India, With Additional Notes on the Birds of Kutch and Gujerat

By R. S. Dharmakumarsinhji. Pp. liii+561+51 plates (33 colour). (Bombay: N. M. Tripathi, Ltd., 1955.) Rs. 50; 112*s*. 6*d*.; 18 dollars.

UNTIL twenty years ago, nearly all the works on Indian birds came from British pens. Then Salim Ali's books began to appear, which rank with the best of any previously published. Now, other Indian authors are following him, and the present volume, written by the brother of the Maharajah of Bhavnagar, and sumptuously produced, is an impressive addition to Indian ornithological publications. Saurashtra is the part of India which lies between the Gulf of Cambay and the Arabian Sea. It appears as Kathiawar on most maps, but Saurashtra is the older name. It is, therefore, a conveniently compact area for field-work. It contains no mountains more than four thousand feet high, and is mostly hilly and undulating. But there is a good deal of salt land and semi-desert (though the rainfall is locally heavy), so that rare or very local species, such as the great Indian bustard, its congener the florican and some of the sand-grouse, breed in fair numbers.

The author writes that he began his observations on birds when he was a schoolboy in England; but the whole of his adult life has been spent in Saurashtra, and this book is a remarkable testimony to the assiduity and care with which he has studied birds, with no neighbour to assist, throughout the years. The book is so full of first-hand and first-rate bird lore that it is not easy to comment on any special passages in a short review. The author is an expert on the eagles, which are among the most difficult birds to distinguish, and his field-notes on their sight-identity are of special value after the recent appearance of some misleading information on some of the same species from Russian ornithologists.

In some cases, rather fuller information would have been desirable. Thus, both the roller (*Coracias garrulus*) and the spotted flycatcher, which occur in this part of India in some numbers on the autumn migration, are claimed as winter visitors. The impression hitherto has been that neither species remains in India during the winter, and it has been assumed that they migrate some fifteen hundred miles across the sea to Africa. It is a pity that the author does not give his evidence in these and some other cases in more detail than a general statement.

The book is fully illustrated, with photographs, many of them taken by the author, and with coloured plates by an Indian artist, Somalal Shah. These plates are variable in quality. The larger birds are often felicitously shown; but the smaller birds look as if they had been based on mouldy skins, and fail to give the distinctive features. However, the book is an important addition to the knowledge of Indian bird-life. H. G. ALEXANDER

ANTIQUITIES IN BRITAIN

Buried London

Mithras to the Middle Ages. By William Thomson Hill. Pp. 192+40 plates+14 maps. (London: Phoenix House, Ltd., 1955.) 25*s*. net.

Furniture in Roman Britain

By Joan Liversidge. Pp. viii+76+69 plates. (London: Alec Tiranti, Ltd., 1955.) 10*s*. 6*d*. net.

MR. THOMSON HILL's book came in on the crest of the wave of public interest which broke—for reasons that are still not altogether clear—on the discoveries which were made in the Walbrook area of London in 1954. "Buried London" is essentially an expansion of newspaper articles dealing with current work in the bombed areas and with the very serious losses to the visible antiquities and historic monuments of the city which resulted from the bombing during the Second World War.

The book is not a scholar's book and the phrase "complete record" in the publisher's note should be read with the reserve appropriate to such declarations. The "complete record" cannot be made until the present phase of recovery of evidence (against time-limits) has ended, to release the energies of the small group of archæologists engaged for the next stage. In its primary form at least, the "complete record" must follow a very different pattern from that presented here.

The present popular enthusiasm for archæology has, inevitably, its good and its bad points. There is a strong element of irony in a situation which creates an earth-shaking sensation out of a discovery like that of the Walbrook Mithræum, in which (important as it was) there was a strong element of luck, while persistently ignoring results of equal historical significance the winning of which called for much greater application and technical resource. But that is how the world wags, and archæologists are not the only sufferers. Unlike most of his professional colleagues, Mr. Thomson Hill has tried to see his subject whole; but too often it has defeated him, and there are some surprising and sometimes serious mistakes.

"Furniture in Roman Times" is written for the general reader, but draws conveniently together for the student a mass of otherwise widely scattered material. Inevitably the amount of Roman furniture actually surviving in Britain is small: it would be even smaller were it not for the use that was made of Kimmeridge shale, a material only less perishable than timber. It is interesting to observe how the long-established Kimmeridge industry adapted itself to the imported classical style as yet another element in the uniform upper crust of material culture beneath which, at least in some parts of the Empire, a native non-Roman element often persisted.

Contemporary sculptures, on tomb-monuments particularly, augment and elucidate the fragments: sometimes conventionally as in the Chester series, sometimes more vividly as in the Simpelveld sarcophagus or the Toilet Scene from Trier. The final impression is that, technical skill and ingenuity apart, Roman furniture was not particularly beautiful and only a liberal use of soft furnishings could have made it comfortable. But as Prof. J. M. C. Toynbee has pointed out in her introduction, studies of this sort make the past live—and that not only for the general reader. For archæology not merely extends knowledge of man backwards in time; it also deepens and enriches understanding by the light that it sheds on aspects of his life that 'history' may fail to touch.

W. F. Grimes

HEAT AND MASS TRANSFER IN COMBUSTION THEORY

Some Fundamentals of Combustion

By Dr. D. B. Spalding. (Gas Turbine Series—Vol. 2.) Pp. x+250. (London: Butterworths Scientific Publications; New York: Academic Press, Ltd., 1955.) 40*s*. net.

THE first of a series of volumes, edited by J. Hodge, of Power Jets, and describing various features of the gas turbine has already been published. The volume under review is the second of the series, and its author, Dr. D. B. Spalding, is reader in applied heat at the Imperial College of Science and Technology, London. The science, though not the subject, of combustion is a relatively new one. Prior to 1939 work had been concentrated on a limited field, concerned with the combustion of premixed gases in the petrol engine, and especially with the phenomenon of detonation, the principal obstacle to progress in the prime mover then of supreme importance in military and commercial applications. A stage had been reached when it appeared that further advances must be made by the chemist rather than by the engineer.

With the increased use of the diesel engine, the rise in cost of fuel and the advent of the gas turbine, the field of combustion research has greatly widened, while detonation has ceased to be of much importance compared with, for example, the necessity for producing high combustion intensity, or with flame stabilization and blow-out criteria. Consequently, a very large literature has grown up; but except to the specialist, difficulty is experienced in reading and interpreting results which the various kinds of authors—engineers, physicists and chemists—present with widely differing emphasis. In this book Dr. Spalding has set out to integrate the most important results of recent research, including a substantial contribution from his own work accomplished while he was at the Department of Engineering, Cambridge, and has in fact succeeded in developing a theory which combines the many isolated fragments of combustion research into a unified whole.

The first two chapters serve as an introduction to thermodynamics and fluid flow, but a serious student of combustion will require a much fuller explanation than is here contained. However, the clearly described and elaborate compressible-flow chart must be of interest to all concerned with high-speed flow of gases, while the thermodynamic approach is clear and rigid. It is, however, in the presentation in the next two chapters of the subjects of heat and mass transfer that the greatest originality lies. Here are developed the differential equations governing heat and mass transfer in the most general cases, such as when chemical reaction is also present. The solution of these equations is not usually possible; but by modifying Fick's Law so that it may be expressed in terms of concentration gradients instead of partial pressures and, when necessary, by assuming that thermal and mass diffusivities are equal, considerable simplification is achieved, so that in some special cases the equations can be solved and in general the form of the solution be derived, in functions of dimensionless groups (just as in heat transfer the Nusselt number is expressed as a function of the Reynolds and Prandtl numbers). It is shown that, with such simplifications, in all cases of mass transfer the results can be expressed in terms of the Reynolds, Schmidt and a new dimensionless number called the transfer number, which may have various simple forms according to the specific problem. The use of the transfer number is fundamental since it shows the different applications considered (for example, vaporization at liquid surfaces, combustion in gas jets and from solid and liquid fuels) to be special cases of a unified whole. The approximations involved are bold, but the quantitative results achieved are well within the usual limits of error associated with problems involving a multiplicity of variables, and lead to a clear conception of the controlling factors of each problem.

Chapter 5 is devoted to combustion processes in which the time-rate is important. There are excellent discussions of the propagation of flames in premixed gases, the conditions for flame extinction, flame stabilization and the criteria for blow-out conditions. The chapter is entitled "Chemical Effects in Combustion", somewhat misleadingly, as the properties discussed are much more physical than chemical. Conclusions developed from the theory are drawn in the short last chapter where there is some interesting criticism of the design of combustion chamber elements. There is no description of practical applications, as a further volume entitled "Combustion Practice" is scheduled to appear in the series.

All in all, this is an excellent book for every worker in combustion research, though its appeal to the practising engineer is much less. The style is crisp and authoritative, the references full, and the author is to be congratulated upon the lucid manner in which he interprets the rather bewildering array of non-dimensional numbers that confronts the student in this subject. He makes their use seem apparent and inevitable, and by their aid brings a hitherto not apparent coherence to a rather untidy subject.

F. D. Robinson

Asiatic Magnolias in Cultivation

By G. H. Johnstone. Pp. 155+34 plates. (London: Royal Horticultural Society, 1955.) 63*s*.

THE author of this work brings to his task not only a love of magnolias, but also a long experience of their culture, and it is particularly where his knowledge of them as living entities illumines the text that the horticulturist will find the pages especially worth perusal. In the first two chapters, where cultivation, pruning and propagation are treated, Mr. G. H. Johnstone has brought together the experience of others, enriched by his own, to provide a helpful guide to any who would essay the cultivation of this genus. The remainder of the text deals with the species individually. Of some forty-five known magnolias, exclusive of hybrids, the Asiatic species, which are here considered, number eighteen, and nine of these latter and their varieties are admirably portrayed in the fourteen coloured plates, mostly from paintings by Miss A. V. Webster.

For each species a diagnosis and formal description is provided, together with a more discursive consideration of matters of identity, culture and other aspects which will appeal especially to those who themselves share Mr. Johnstone's enthusiasm for growing magnolias. They range from tall trees such as the magnificent pink-flowered *M. campbellii* from the Himalayas or *M. obovata* from Japan, to shrubs such as the charming *M. sinensis* from China, with its exquisite drooping flowers and crimson stamens. The flowering period extends from the bleak days of March, when the white stars of *M. stellata* burst through their furry covering, to August and September, when *M. sieboldii* and *M. delavayi* contribute to the garden's fragrance as well as to its beauty.

Many species are diploid, with 38 chromosomes; but the members of the Yulania section, to which the beautiful *M. denudata* introduced from east China by Banks in 1780 belongs, are all hexaploids with 114 chromosomes, while the Chinese *M. liliflora* is a tetraploid with 76 chromosomes. The genus, in fact, presents a great diversity of interest to the student of plant life, and æsthetic attraction and problems of cultural skill to the grower, so that those who peruse this volume should feel indebted to Mr. Johnstone for its production and to the Royal Horticultural Society for its publication at what, in these days, must be regarded as a very reasonable price.

E. J. SALISBURY

Scientific and Technical Societies of the United States and Canada

Part 1: Scientific and Technical Societies of the United States. Compiled by the Library, National Academy of Sciences—National Research Council. Part 2: Scientific and Technical Societies of Canada. Compiled by John R. Kohr, National Research Council, Canada. Sixth edition. (Publication 369.) Pp. 447. (Washington, D.C.: National Academy of Sciences—National Research Council, 1955.) n.p.

BLESSED with vast rich natural resources, the North American people have not been slow to develop an economic system that seems naturally adapted to the rapid exploitation and enjoyment of these resources and a high standard of scientific and technological achievement that is both the outcome of economic growth and the means by which further and swifter advances are made. Probably no other people are more scientifically minded, and an indication of this is given by the present edition (the sixth) of the "Handbook of Scientific and Technical Societies of the United States and Canada".

As is remarked in the preface, during the twenty-seven years since the first edition, a large number of new scientific and technical organizations have been started in North America, and though they may be concerned with highly specialized topics and their membership small, the fact of their establishment is worth recording. Glancing over the pages, the reader is impressed both by the very large number of regions or localities that are associated with a particular organization and by the great wealth of topics that form the basis of the various organizations.

It is to be noted, too, that the earlier editions of this handbook covered both societies and institutions; but the latter are now omitted, as also are such other organizations as trade associations with research activities.

There are 1,506 entries for the United States and 206 for Canada, occupying more than four hundred pages. The size and content of the entries vary somewhat; but typical of the details given are the history of the society, its purpose, membership, meetings, library, research funds and medals, etc., and publications. The two indexes, one for the United States and one for Canada, are of the omnibus type: they include a subject classification of the activities, purposes and research funds of the societies (with the subjects appearing in capitals); periodicals (in italics); names of research funds, prizes, medals, etc., and changes in names of societies after 1948. The book is prepared jointly by the National Academy of Sciences—National Research Council of the United States and by the National Research Council of Canada. As such it bears the stamp of authority and can be relied upon.

The Chemistry and Fertility of Sea Waters

By Dr. H. W. Harvey. Pp. viii+224. (Cambridge: At the University Press, 1955.) 30*s*. net.

THIS excellent book deals more fully with the fertility of sea water than did its predecessor, "Recent Advances in the Chemistry and Biology of Sea Water" (Cambridge, 1945). Dr. H. W. Harvey recognizes five major processes, which in his unsemantic way he calls "conditions". Briefly they are: illumination; replenishment of nutrient salts; grazing of plants by animals; removal of plants from the upper, photosynthetic, layer of the sea by turbulence; and metabolism, which is at least partly governed by temperature. Chapter 5 collects and sets out succinctly the published effects of those processes on the growth of the plants in the plankton. A shorter chapter suffices for what is known about the production of animals. The two chapters together mark a notable advance in elaboration of knowledge, compared with that behind Chapter 10 of the preceding book—worth, with the better paper and printing, the extra cost.

The new book also gives more information on the chemistry, including how to determine phosphate much more accurately than has sufficed hitherto, and therefore less rapidly. Other additions on chemical methods are perhaps more useful, and all are described more precisely than in the earlier books. Harvey's study of sea water and the related biology forms an essential part of twentieth-century oceanography, and chemists may care to note this advance in their own subject in an unusual field.

MICHAEL GRAHAM

Optical Properties of Thin Solid Films

By Dr. O. S. Heavens. Pp. vii+261. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1955.) 35*s*. net.

WITHIN recent years the interest in the field of optical properties of thin solid films has been greatly stimulated and many papers have been published, due largely to the development in the methods of preparing thin films and their examination by optical and electron-microscopic techniques. Consequently, a large amount of information about the nature and behaviour of thin films and their optical properties has become available. Dr. O. S. Heavens's book is therefore a timely and welcome addition to the existing literature.

There are seven chapters, including the introduction. The second chapter is devoted to the techniques for the production of films, with special emphasis on the evaporation method which is so commonly employed these days. The next chapter briefly describes the structure of solid films as revealed by electron-optical studies. The fourth chapter is devoted to the calculation of the optical properties of thin films, namely, the reflexion-transmission coefficients and phase changes at a single film or a system of layers. This chapter will be specially welcomed by those who are starting work in the field and want to have a connected account for their calculations. In the next two chapters are given a discussion of the methods for the measurement of optical constants and thickness of the film, followed by a general survey of the results obtained. Many interesting applications of thin films in the laboratory and industry are covered in the last chapter.

The subject-matter of the book has been well arranged and is presented in a very clear style. Each chapter is followed by a list of references to the original papers. The book will be of use both to the research worker studying optical properties of thin films and those engaged in industry.

Reagent Chemicals and Standards, with Methods of Testing and Assaying Them

Also the Preparation and Standardization of Volumetric Solutions and Extensive Tables of Equivalents. By Joseph Rosin. Third edition. Pp. x+561. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1955.) 70*s*. net.

THE author of this book, formerly chief chemist and chemical director of Merck and Co., has had considerable experience of the testing of chemical reagents and is an expert in the field. In view of the rapid advances in analytical chemistry during recent years, some forty-five new reagents and solvents have been added to this edition. In each entry the physical properties and standards of the substance are given, and the methods used in testing for impurities and, in many cases, for assay are set out in satisfactory detail. Since the standards are now exacting, sensitive methods involving new reagents are often necessary, and it would be hard to find these in the literature. Some references to recent publications are given.

The book is a valuable storehouse of information which should be available in every chemical laboratory. Manufacturers of chemicals should in particular find it of great service in their laboratories; but it has a wider field of usefulness, since in preparative and research work the purity of the materials is often essential, and the methods of testing for traces of likely impurities should be at hand. In the case of substances used as standards in volumetric analysis, the best methods of assay are given. Indicators and solvents are included.

There seem to be scarcely any inaccuracies in the book, which covers in detail a wide field; but 'dithionate' on p. 413 should be 'dithionite', and the name Kolthoff is given incorrectly on p. 498. This is a sound and informative book which will be welcomed by all chemists. The paper, printing and binding are excellent.

Modern Gas Analysis

By Paul W. Mullen. (Interscience Manuals.) Pp. ix+354. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1955.) 5.50 dollars.

ABOUT two-thirds of this pocket-sized book are devoted to conventional absorptiometric methods of gas analysis, and the remainder to instrumental methods. It thus provides a wide survey of current practice; but the second part in particular is brief, and more information would be needed for the use of all the techniques described. Space has, however, been used prodigally in other ways, and it seems surprising that, among other examples of the historical approach, five pages should be devoted to the derivation of $PV = nRT$, or that a picture of a Fortin barometer which shows few details should occupy nearly a whole page. Most of the large number of illustrations are of the pictorial type found in catalogues, and some demonstrate little beyond the supplier's name; it would have been preferable to leave more room for the text by reducing the number of illustrations of American equipment and including a higher proportion of diagrams of universal application.

The book is well produced, attractive in appearance and gives a readable account of its subject which may be useful to a non-specialist such as myself; but because of its abbreviated treatment, it is unlikely to appeal to the gas analyst.

D. Ambrose

Parva Naturalia

By Aristotle. A Revised Text with Introduction and Commentary by Sir David Ross. Pp. xi+354. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 40*s*. net.

THIS book will be valued by all Aristotelian scholars, and by naturalists interested in the early formulation of their science. Present-day psychologists, too, if they consult it, may find a few surprises. For example, the work contains the oldest general formulation of the laws of association. It is well known that some examples of these laws occur in Plato's "Phædo", but the originality of Aristotle's concept is the introduction of contrast. A reference of great historical significance is that to 'Aristotle's experiment' (frequently mentioned by philosophers) in which a marble, if held between the crossed first and second finger of either hand, is 'felt' as two objects. The explanation of the effect is commonly ascribed to our involuntary separation of the contacts as distinct in space.

These are only two of the numerous problems contained in the collection; much else deserves careful thought at the current level of observational technique. It is scarcely necessary to add what a delight the whole volume is—the result of the hand of Sir David Ross upon it.

F. I. G. Rawlins

POLAR WANDERING: A MARATHON OF ERRORS

By Dr. W. H. MUNK*

Department of Geodesy and Geophysics, University of Cambridge

"THE subject of the fixity or mobility of the earth's axis of rotation in that body . . . [has] from time to time attracted the notice of mathematicians and geologists. The latter look anxiously for some grand cause capable of producing such an enormous effect as the glacial period. Impressed by the magnitude of the phenomenon, several geologists have postulated . . . a wide variability in the position of the poles on the earth; and this, again, they have sought to refer back to the upheaval and subsidence of continents." With these words George Darwin introduced his paper[1], "On the Influence of Geological Changes on the Earth's Axis of Rotation"; it occupies forty-two pages in the *Philosophical Transactions*, and its mathematical complexity is in proportion to the length. The paper was published in 1877 when Darwin was thirty-two years old; it is the first of his seventy-two papers on cosmology. Yet this was to remain the only serious study of the dynamics of polar wandering until Gold[2] reopened the problem in a succinct article in *Nature* in 1955. Gold's conclusion differs from Darwin's, but this is only the latest chapter in an extensive, and sometimes heated, controversy that has been going on for seventy years.

Darwin set himself the following problem: at time 0 some continents suddenly commence to rise, others to fall, and the movements continue at a uniform rate thereafter. What would be the position of the axis of rotation if the Earth is (*a*) a rigid solid, (*b*) a viscous fluid? We now consider that the Earth is better described as an elastic solid. Darwin did not consider this case; neither the evidence nor the elastic theory had been developed. We are here concerned only with the orientation of the axis in the body of the Earth; the orientation in space is scarcely altered. It is therefore convenient to refer to the geographical location of the poles of rotation, where the axis pierces the crust.

Darwin's solution (ref. 1, pp. 282–83) consists of oscillatory terms like

$$\exp(-\alpha t)\cos\omega t \qquad (1)$$

plus others that remain after the initial oscillation has become damped out. These have the components (disregarding for the moment a slight separation between axes of figure and rotation):

$$x = \frac{\alpha(\omega^2-\alpha^2)}{\omega^2+\alpha^2}u - \frac{\omega^2}{\omega^2+\alpha^2}ut$$
$$y = -\frac{2\omega\alpha^2}{\omega^2+\alpha^2}u + \frac{\omega\alpha}{\omega^2+\alpha^2}ut \qquad (2)$$

u is a measure of the rate of upheaval, x is the polar displacement toward the centre of upheaval and y at right angles to it.

For undamped oscillations of a rigid Earth, $\alpha = 0$, and

$$x = -ut,\ y = 0 \qquad (3)$$

For reasonable continental upheavals, these solutions must be limited to such times that ut is of the order of a degree of latitude at most, according to Darwin; actually one mile might be a better upper limit. In any event, there can be no appreciable polar wandering on a rigid Earth. The opposite extreme, that of great fluidity, corresponds to large α, and to

$$x = -\alpha u,\ y = -2\omega u \qquad (4)$$

so that x can be made arbitrarily large by taking α arbitrarily large.

Darwin is explicit in the interpretation of his solution: "If the earth be sensibly rigid . . . the geographical path of the axis is very nearly the same as is due merely to the geological deformations of the earth's shape; but if the earth be more or less plastic, . . . the dynamical reactions introduced are such as more or less to modify the geographical path of the axis. In the case of great plasticity these reactions would suffice to alter entirely the character of the path". We have therefore clearly a state of things in which the pole may wander indefinitely from its primitive position. "On this hypothesis, as in successive periods the continents have risen and fallen, the pole may have worked its way, in a devious course, some 10° or 15° away from its geographical position at consolidation, or may have made an excursion of a smaller amount and have returned to near its old position."

Whether or not there had been polar wandering was therefore not a question of dynamics, but depended on whether the Earth was taken as plastic or rigid. The decision was outside the scope of Darwin's analysis, though he favoured the latter alternative: "But Sir William Thomson has shown that the earth is sensibly rigid; and in any case the earth is not a viscous fluid, properly so-called, although it may be slightly plastic".

What was Kelvin's evidence for a rigid Earth? His original argument[3] was by way of reference to Hopkins, "who first adduced the phenomena of precession and nutation to disprove the hypothesis that the solid part of the Earth's mass is merely a thin shell". But this argument is wrong, because precession is caused by the pull of the Sun on the equatorial protuberance regardless of whether it is fluid, elastic or frozen. Kelvin was questioned on this point by Newcomb, and in a presidential address to the British Association[4] Kelvin asked his audience to cross out what he had written on this subject in "Natural Philosophy". (I found the copy in the University Library, Cambridge, to have been defaced accordingly.) Unknown to Kelvin and Newcomb, the error had already been pointed out by General Barnard[5].

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Darwin[1] refers to Kelvin's retraction of precession as an argument for rigidity, but adds that Kelvin ". . . adduces, however, a number of cogent arguments on this point". Curiously enough, Kelvin refers here to a paper by George Darwin's great father[6] entitled "Observations on the Parallel Roads of Glen Roy and other parts of Lochaber in Scotland, with an attempt to prove that they are of Marine Origin", in which it is said that the Earth as a whole takes approximately the figure due to gravity and centrifugal forces, because of the fluidity of the interior and the flexibility of the crust. To this statement Kelvin raises the following two objections in his British Association presidential address[4]: (1) "But alas, for this 'attractive sensational idea' . . . that a molten interior to the globe underlies a superficial crust, its surface agitated by tidal waves, . . . the solid crust would yield so freely to the deforming influence of sun and moon that it would simply carry the waters of the ocean up and down with it, and there would be no sensible tidal rise and fall of water relatively to land . . ."; that is, unless the crust consisted of "preternaturally rigid matter", far more rigid than steel; (2) that the "solar semiannual nutation must be largely, and the lunar fortnightly nutation enormously, affected by interior liquidity. . . . This conclusion is absolutely decisive against the geological hypothesis of a thin rigid shell full of liquid". But the argument is not decisive if we ascribe to the mantle a behaviour characteristic of many materials, whereby it responds almost as an elastic solid to disturbances of short period, but flows in response to stress of long duration. I think Darwin's suggestion was well taken[1]: "it seems quite possible that the earth may be sensibly rigid to the tidal deforming influences of the sun and moon, and yet may bring itself back from any considerable departure from a form of equilibrium to approximately that form". Kelvin's foregoing arguments may have had something to do with a letter George Darwin was to receive from his father two years later[7]: "Hurrah for the bowels of the earth and their viscosity and for the moon and for the Heavenly bodies . . . and for my son George (F.R.S. very soon) . . .".

But Kelvin[4] was not yet contented with the two preceding arguments: "But now thrice to slay the slain: suppose the earth this moment to be a thin crust of rock or metal resting on liquid matter; its equilibrium would be unstable! And what of the upheavals and subsidences? They would be strikingly analogous to those of a ship which has been rammed —one portion of crust up and another down, and then all down. Now whatever may be the relative densities of rock, solid and melted, at, or about, the temperature of liquefaction, it is, I think, quite certain that cold solid rock is denser than hot melted rock; and no possible degree of rigidity in the crust could prevent it from breaking to pieces and sinking wholly below the liquid lava".

"And thrice he slew the slain"? The quotation may have been more apt than Lord Kelvin intended. For later during the feast the slain come back to plague the king, and Timotheus cries: "Those are Grecian ghosts, that in battle were slain, . . . behold how they toss their torches on high . . .".

Darwin himself seems to have been well enough convinced by Kelvin's persuasiveness[8]: "A third opinion, contended for by Sir William Thomson [Lord Kelvin], and of which I am myself an adherent, is that the earth is throughout a solid of great rigidity . . .". Thirty-one years later, when his paper was reprinted among his collected works, he wrote[9]: "The conclusions arrived at in my paper are absolutely inconsistent with the sensational speculations as to the causes and effects of the glacial periods which some geologists have permitted themselves to make". Darwin remained on close terms with Kelvin, a friendship that had, in fact, begun with the selection of Kelvin by the Royal Society as referee for the paper here under discussion. An alternative derivation due to Kelvin is included as Appendix *C* to Darwin's paper. Kelvin, according to Darwin, "seemed to find that on these occasions the quickest way of coming to a decision was to talk over the subject with the author himself". Darwin considered that all his work on cosmogony "may be regarded as the scientific outcome of our conversations of the year 1877; but for me at least science in this case takes the second place".

I must refer to one more aspect of the Kelvin-Darwin discussion of polar wandering. Kelvin's arguments for a rigid Earth denied the possibility of polar wandering within the framework of Darwin's analysis. But this should not imply that Kelvin was opposed to shifting the pole over large distances. Far from it. In a passage often quoted by those who favour large polar displacements, Kelvin said[4]: "Considering, then, the great facts of the Himalayas and the Andes, and Africa and the depths of the Atlantic, and America and the depths of the Pacific, and Australia, and considering further the ellipticity of the equatorial section of the sea-level, estimated by Capt. Clarke at about 1/10 of the mean ellipticity of meridional sections of the sea level, we need no brush from the comet's tail (a wholly chimærical cause which can never have been put forward seriously except in ignorance of elementary dynamical principles) to account for a change in the earth's axis; and we may not merely admit, but assert as highly probable, that the axis of maximum moment of inertia and the instantaneous axis of rotation, always very near one another, may have been in ancient times very far from their present geographical position, and may have gradually shifted through 10, 20, 30, 40, or more degrees without at any time any perceptible sudden disturbance of either land or water". These views were reprinted in Kelvin's "Collected Works"[10] in substantially their original form.

So far as I can see, Kelvin reasoned as follows: the surface of the Earth is divided into quadrants; in the northern hemisphere a rise is centred at 0° longitude (say) and a fall at 180°, in the southern hemisphere a fall at 0° and a rise at 180°. For a maximum crustal displacement of 10 cm. the pole of a rigid earth is shifted by 0·1″. Then by what Kelvin calls a "simple effort of geological calculus" he finds that for a corresponding surface displacement by 10 km. the pole is moved through nearly 40° latitude. Kelvin had assumed the Earth to be sufficiently rigid to sustain a distortion commensurate with the dimensions of the equatorial bulge. Of course, this must lead to appreciable polar wandering, but it would seem to be the hard way of doing it.

We return to Darwin's solution (equation 2). It may have been noticed that the first terms in x and y have the dimensions length/(time)^2 instead of length. This is the result of a simple algebraic error made earlier in the derivation. The mistake was discovered by Lambert[11]; the corrected equations are given by Jeffreys[12]:

$$x = \frac{\alpha(\omega^2 - \alpha^2)}{(\omega^2 + \alpha^2)^2} u - \frac{\omega^2}{\omega^2 + \alpha^2} ut$$
$$y = -\frac{2\omega\alpha^2}{(\omega^2 + \alpha^2)^2} u + \frac{\omega\alpha}{\omega^2 + \alpha^2} ut \qquad (5)$$

All terms now tend to zero as α becomes infinite. There can be no polar wandering no matter how fluid the Earth is. This conclusion contradicts the previous result (equation 4).

For simplicity we now restrict ourselves to the case $\alpha \ll \omega$. Equation (5) can then be written

$$x = (\alpha/\omega)(u/\omega) - ut, \quad y = 0 \qquad (6)$$

The approximation $\alpha \ll \omega$ is amply justified by the observation that the damping of the free nutation requires many periods. Subject to the same assumptions and restrictions, I find, in an independent derivation,

$$x = (\alpha/\omega)(u/\omega) - ut - \tfrac{1}{2}\alpha ut^2, \quad y = 0 \qquad (7)$$

The solutions differ by the term in t^2, and this term yields substantial polar wandering as a consequence of surprisingly small continental upheavals. Equation (7) has the pole move at a constant *acceleration* in response to a constant *velocity* of upheaval. Had Darwin chosen the simpler (and sufficient) example of a sudden vertical displacement, the result would have been a polar wandering at constant velocity. My solution agrees on all essential points with Gold's conclusions arrived at by non-analytical reasoning.

To point out the difference between Darwin's (corrected) solution, and Gold's conclusion, we must return to the basic considerations that underlie Gold's hypothesis. The pole of figure is a position where the axis of figure (about which the moment of inertia is a maximum) pierces the crust. For a rigid Earth the displacement of the pole of figure by $x = -ut$, $y = 0$ is entirely determined by the prescribed upheaval. The pole of rotation circles the pole of figure once every ten months. In the case of a yielding Earth, there is an additional displacement of matter as the geoidal protuberance attempts to adjust to the disturbed position of the rotation axis. The total displacement of the pole of figure is then the sum of displacement of the geoidal pole and that determined by the prescribed upheaval. From dynamic considerations one finds that the velocity of the rotation pole is proportional to its separation from the pole of figure, and from elastic (or plastic) considerations that the velocity of the geoidal pole is proportional to its separation from the pole of rotation. It is, according to Gold[2], "as with the ass and the carrot hanging from a stick held by the rider". The geoidal pole pursues the rotation pole, the rotation pole pursues the pole of figure, which in turn is continuously being displaced by the geoidal pole.

Darwin's reasoning is implicit in his equations 1–4 (ref. 1, p. 282). The sum of the four equations is equivalent to the above-mentioned dynamic considerations. But equations (3) and (4) state that the geoidal pole moves at a rate proportional, not to its separation from the rotation pole, but to the separation of the rotation pole from the pole of figure. I cannot think of any reason for this type of behaviour; it would be consistent, for example, with a stationary solution for a liquid, rotating Earth where the poles of figure and rotation are united, with the geoidal pole being elsewhere.

Darwin obtained his four equations from what he calls geometrical, rather than dynamical, considerations. The important thing is that they do not follow from a deductive argument, and he seems to have gone astray in the formulation of the last two equations. When these are modified in the above sense, then equations (7) follow once more. On the basis of the present development of the theory of elasticity, which was not available to Darwin, it is possible to proceed from fundamental principles to a solution without any break in the deductive argument, and this is, in fact, the method whereby equation (7) was derived.

We are left with three solutions: Darwin's original solution (2) made polar wandering possible; the corrected solution (5) made it impossible; and the modified solution (7) makes it easy. That the final outcome is not in contradiction to the original conclusion is a result of having made an even number of errors. But there is an important difference; equation (2) requires a large value of α for polar wandering, (7) does not, and is in fact based on the assumption that $\alpha \ll \omega$.

In the light of these developments, the many papers that have centred on Darwin's work assume grotesque proportions. Long before Darwin wrote, Comte de Buffon had founded the 'Catastrophic School' of polar wandering to account for palæoclimatic evidence. Darwin clearly hoped his paper would put certain restraints on contemporary arguments for polar wandering by Lubbock, Delabeck, Evans and others. In fact, it was followed by a renewed wave of enthusiasm for large polar displacements, which reached its peak in "Die Pendulations Theorie" of Reibisch and Simroth. Darwin's student, the astronomer Brown, countered these claims with apparent exasperation[13]: "[Darwin's] conclusion, now well known to astronomers, but frequently forgotten by geologists even at the present time is against any extensive wanderings of the pole during geological times". In 1914, Barrell[14] reviewed "The Status of Hypotheses of Polar Wanderings" as follows: "Geologists and biologists may array facts which suggest such hypotheses, but the testing of their possibility is really a problem of mathematics. . . . Notwithstanding this, a number of hypotheses concerning polar migration have been ingeniously elaborated and widely promulgated without their authors submitting them to these final tests. . . . Others, of more logical mind, recognizing the need of mathematical justification, have thought to find a qualified support in the work of Kelvin and G. H. Darwin. . . . The work of Darwin, instead of permitting hypotheses of polar wanderings, offers the most convincing proof which is available that migrations of the axis of the earth sufficiently extensive to be of geological importance have not occurred [*sic*]. . . . His [Darwin's] papers seem to have checked further speculation upon this subject in England, but, apparently unaware of its strictures, a number of continental geologists and biologists have carried forward these ideas of polar wandering to the present day. . . . Does not the history of the subject show the dangers of over-specialization within one division of science with the consequent putting forth of hypotheses regardless of the verdict of related Sciences?"

In this controversy between physicists and geologists, the physicists, it would seem, have come out second best. They gave decisive reasons why polar wandering could not be true when it was weakly

supported by palæoclimatic evidence; and now that rather convincing palæomagnetic evidence has been discovered[15], they find equally decisive reasons why it could not be otherwise.

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BOOLE'S "THE LAWS OF THOUGHT"

By F. I. G. RAWLINS

THE Royal Irish Academy has done well to collect and issue a series of papers* commemorating the appearance of "The Laws of Thought" by George Boole in 1854. The occasion was a centenary celebration in Dublin, and here is a permanent record, bearing witness both to the unique character of the book itself, and in parallel, so to say, to the remarkable personality of its author. If ever a publication reflected the innermost being of its originator, this volume assuredly did. Its production, moreover, stands as a monument to the foresight of the electors to the chair of mathematics at Queen's College, Cork, who appointed a candidate without a university degree, and devoid of formal academic training. It is rather as if a similar choice had been made of Ramanujan many decades later, before he went to Trinity College, Cambridge, to carry all before him.

Most appropriately, Sir Geoffrey Taylor opens the series with a graphic account of his grandfather's life. And what a life it must have been; serene, highly disciplined, creative at every stage, both in research and in the task of imparting knowledge. For even when Boole was school-mastering in Lincoln as little more than a youth he was experiencing the joy of discovery, as he read and mastered the works of the French mathematicians. Alongside all this, he taught himself several languages, as if to foreshadow the development of semantics as the century wore on.

Boole had a great appreciation of the place of tranquillity in the intellectual life. We read of him taking a "solitude à deux" with a friend to the Alkborough Hills near his peaceful Trent, and sitting down alone under a bush in the evening. From this excursion arose the precursor of his analytical studies which he later improved and expanded in "The Laws of Thought". At times his inclination seems to have been towards algebraic methods rather than in the direction of geometry, believing the former to be the more powerful instrument. But as we shall see later, this was no lopsided view. His grasp was so sure that, analyst as he sometimes was, history will credit him as a great architect in synthesis.

How exactly did this come about? The answer is to be found in Boole's attitude to Nature. He believed profoundly that there was such a thing as unity *of* Nature, and unity *in* Nature. In these two concepts, which went far to mould the entire pattern of his life, he approximated to Leonardo da Vinci, with his deep veneration for natural law. The method of Boole is based upon this one-ness, and enmeshed in it are the seeds from which has flowered much of the propositional calculus as we now have it, and a great part of the powerful machinery of modern logistics. It must not be too readily deduced from this, however, that the meta-sciences of to-day spring directly from "The Laws of Thought"; what has in fact happened is that out of traditional logic has appeared a means whereby it has become possible to raise such a majestic structure that the elements of Aristotelian thought still embedded in it comprise but a minute fraction of the whole. It is an example on the grand scale of the eternal verity that nothing can be quickened except it die. The sower of that particular harvest was George Boole.

We can now, with this in mind, attempt some appraisal of the method of this remarkable man, and we shall not get far without observing certain features in common with the outlook of Alfred North Whitehead. It is probably no accident that much the same logical pressure acted upon the mind of Boole as it did much later upon the authors of "Principia Mathematica". The essence of his method is to begin with things rather than words; with objects before concepts. Then follows the paramount need to train the mind by rigorous exercise, including the working out of numerous examples. One may compare this with Whitehead's belief in the use of the simplest possible apparatus, to squeeze the last drop of juice out of any problem amenable to experiment. Just as Leonardo da Vinci took infinite pains (somewhat against the grain) to study the works of Archimedes, so we find Boole ever ready to relate his abstractions to things as we find them. His insistence upon the acquisition of a beautiful and legible handwriting gives us a clue to the importance which he attached to means as well as ends. He was human enough to seek relief from pure speculation by resorting sometimes to "mechanical employments", while conversation he regarded as an entertainment, not as an occasion for strife.

Strong traditionalist as he was—as we have already seen—Boole's concept of the construction of a physical science has a present-day familiar look. In "The Laws of Thought" he finds four stages: namely, observation, presumption (that a law exists), experimental tests, and the investigation of causes. In addition, his emphasis upon increasing probability towards the limit of certainty as confirmatory data increased shows how sure an insight he had of a

* Proceedings of the Royal Irish Academy, Vol. 57, Section A, No. 6: Celebration of the Centenary of "The Laws of Thought" by George Boole. Pp. 63–130. (Dublin: Hodges, Figgis and Co., Ltd., 1955.) 6s.

methodology well ahead of his time. This is noteworthy when one recollects that Boole was working at a period when laboratory techniques were very limited and—supposedly—his own contacts with them of the most slender kind.

In passing from here to some evaluation of Boole's place in logic, the elementary fact of history—that the subject had been static "at the same level of very elementary deduction" for some two thousand years—throws into relief the achievement of infusing new life in the form of a conscious mathematical logic into something which had eluded Leibniz and Lambert many years before. All this was propounded in the "Mathematical Analysis of Logic" (1847), and elaborated in "The Laws of Thought". In essence, Boole set about calculating as an algebraist would, afterwards eliminating such terms as were incapable of a logical interpretation. According to him, however, the equality $xx = x$ is unique. In ordinary algebra this is only true for $x = 1$ and $x = 0$, whereas in logic it holds for all values of x. From this he goes on to assume that the laws of his algebra only exceed those of ordinary algebra in this one particular. A number of criticisms have been made of Boole's system both in regard to mathematical rigour, and touching the æsthetic point that in some degree it lacked elegance. No doubt, as one commentator observes, there were some tares among the wheat, and they grew together until the harvest. Time has exterminated the chaff.

A trio of papers in the collection under notice brings the story of Boole's genius up to date by a discussion of the relation of his methods to contemporary many-valued logics, his concept of a function, and the influence of institutionalism upon the classical algebra of logic. Finally, comes a contribution dealing with an engineering application of Boolean algebra, which turns out to be an extremely powerful calculus for the determination of electrical circuits comprising two-state switches, that is, those that can be only 'on' or 'off'. In the case of complex problems in telephony, it can make possible major advances in communication theory, by simplifying equations otherwise almost unmanageable in practice.

In brief, the life and work of George Boole as reflected in "The Laws of Thought" are the perfect illustration of the truth of Whitehead's dictum: "You may not divide the seamless coat of learning".

THE COLE MUSEUM OF ZOOLOGY

UNIVERSITY OF READING

IT is fifty years since the appointment of Prof. F. J. Cole to the Department of Zoology in University College, Reading (now the University of Reading). One of the factors that contributed to Reading's rise to the status of a university was the fact that several men and women of high quality identified their careers with her, and Prof. Cole was one of them. Soon after his arrival he started to build up a museum of zoology, and when he retired in 1939 he had the satisfaction of seeing his Department endowed with one of the finest teaching museums in Great Britain. An appreciative Council decreed that it should remain as a permanent memorial to him with the name of 'The Cole Museum of Zoology'.

Small though the Department was, it was from the beginning the special duty of one of the members of the staff to care for the growth and maintenance of the Museum. From 1912 until 1919 this was Miss (now Dr.) Nellie B. Eales, and from 1921 to the present time Mr. W. E. Stoneman has held the curatorship.

The exhibits now number more than three thousand, and each is described in the manuscript catalogue, where references to original publications are found and drawings help to interpret intricate parts. This is the source-book for the Museum's history, and it is appropriate to celebrate its jubilee by recalling some of the highlights.

Prof. Cole appealed to zoological friends all over the world, asking for particular animals in accordance with a careful plan. Prof. Ijima of the University of Tokyo, a world authority on the Porifera, collected and prepared in his own laboratory the magnificent series of Hexactinellid sponges. He, moreover, went to sea six times before he succeeded in dredging from the depths of the ocean the fine sea-lily (*Metacrinus*) which now adorns the Echinoderm case. Skeletons of a record python and an orang were contributed by Dr. Hanitsch, formerly director of the Raffles Museum, Singapore. Mr. Alfred Palmer, by a generous donation, made possible the purchase of a fine gorilla skeleton to complete the Huxleyan series—gibbon, orang, chimpanzee, gorilla, man. Captain C. R. S. Pitman, when game-ranger of Uganda, sent such animals as the tree pangolin and the lung-fish, *Protopterus*. The Australian Government presented specimens of the echidna and the platypus, from which dissections, skeletons and stuffed skins were prepared. Dr. Johannes Schmidt provided a set of stages of the *Leptocephalus* larva (eel) up to its metamorphosis. An officer of an Antarctic whaling ship prepared a group of specimens to illustrate the auditory organ of the whale, and a beautiful and perfect exhibit is the result. From the *Discovery* collections also many gifts were received. Old students going abroad were briefed to obtain specimens, and to them the Museum owes its Java pangolin, West African manatee, bats and monkeys, Central African hyrax, giant millipedes and scorpions and Mauritian lemurs and tenrecs.

The fullest use was made of all this valuable material. A single *Cryptobranchus* from Japan yielded a complete skeleton and preparations of the heart, arterial arches, gut, renal and reproductive organs, as well as a stuffed skin.

Dissections form a major part of the collection, and they include numerous injections of blood vessels, lymphatics and air-sacs. A former student, Dr. D. H. Tompsett, prosector at the Museum of the Royal College of Surgeons, prepared an exquisite Marco resin cast of the pulmonary vessels and bronchi of a sheep, and another of the cavities of the human brain, both of which were presented by the College.

Transparencies, in which the bones and cartilages are stained to show the skeletal parts *in situ*, have been made by Mr. Stoneman. There are wax models

of invertebrate larvæ, mostly prepared by Mr. W. Rogers, laboratory steward, from the fine collection of microscope slides of marine larvæ made at Port Erin by the late Mr. H. C. Chadwick and purchased from him. Gastropod development is illustrated by copies of Dr. Doris Crofts's models of *Haliotis* larvæ.

Among the Museum's treasures are numerous delicate preparations of medusæ, corals and sea-pens with polyps expanded, from Naples Marine Biological Laboratory, preserved especially for the Museum by Cavaliere Salvatore Lo Bianco. They were probably the last specimens preserved by that greatest of preparators of marine material.

At one time the Museum of the Royal College of Surgeons, with its long history from Hunter to R. H. Burne, was Reading's nearest parallel and exemplar; but this was destroyed by bombs in the Second World War. The Cole Museum was built up probably in the last years when such things were possible. Thirty years ago it was adequately housed in the room which it still occupies, and now congests. It is greatly to be hoped that on the new University site a worthy building will be planned for the Cole Museum and that provision will be made to maintain what is a unique asset, not only for the University of Reading, but also for the entire country. Since this project may be many years ahead, we look to the University authorities to preserve the Museum intact, perhaps, if necessary, in a temporary building big enough for the whole collection to be adequately displayed and used.

OBITUARIES

Prof. Kurt G. Stern

Kurt G. Stern died on February 3 of a heart attack in St. Mary's Hospital, London, in his fifty-first year. Born in Tilsit, he attended elementary and grammar school there and moved to Berlin for his higher education, where he received his Ph.D. in 1930 at the University. In the following year he won a Rockefeller fellowship, worked for one year at the Rockefeller Institute in New York, and for two more years at the Courtauld Biochemical Institute in London. When he was to return to Germany in 1935, the Nazis had taken over and Dr. Stern decided to accept a research fellowship at Yale University in New Haven, where he became a research associate in 1938 and joined the Overly Research Foundation in 1942. Two years later he was offered a post as research associate and adjunct professor at the Polytechnic Institute of Brooklyn, in which position he remained until his death.

Stern's influence on the development of biochemistry rested on the combination of several distinguished qualities: he was an excellent lecturer and an inspiring teacher; he was a meticulous experimentalist with an innate urge for precision and accuracy, and on top of it all he had a never-failing flair for selecting problems of general importance and far-reaching significance. He was strongly attracted by questions connected with the fundamental aspects of life, and hence biochemistry, biology and physiology were the sources from which he selected his problems; but with equal firmness he adhered to the exact quantitative and reproducible methods of physical chemistry and physics. As a consequence, for many years, his activities developed in the borderland between different sciences, taking problems from one and solving them with methods taken from another. In this difficult, self-assigned task, Stern succeeded not only in introducing precise methods in fields where they were unknown, but also in inventing and constructing many new instruments for the purification and characterization of biological objects, particularly enzymes, virus, proteins and nucleic acids.

While he worked and taught at the Polytechnic Institute of Brooklyn, he also acted as chemical consultant at the Montefiore Hospital in the Bronx; and it was a fitting expression of his constant tendency to bridge gaps between different sciences that each day he moved in the morning through the corridors of a busy hospital at one end of New York's metropolitan area, and in the afternoon lectured and supervized fundamental research in the laboratories of the Polytechnic Institute of Brooklyn at the other end. This type of work he liked; thus he contributed innumerable important results, and in both fields he was highly esteemed and liked by his colleagues and collaborators.

Dr. Stern's activities and efforts won him many recognitions and honours. He served as chairman of the Protein and Nucleic Acid Week of the Gordon Research Conferences; he was the secretary of the Planning Committee of the Chaim Weizmann Institute in Rehovoth; he was president of the American Society of European Chemists and Pharmacists and he served on many occasions as chairman of special symposia arranged by the American Chemical Society, the New York Academy of Sciences and in other scientific and technical organizations. He was awarded in 1953 the Pasteur Medal of the French Society of Chemistry and Biology.

His great scientific achievements and professional success were equalled by his warm, friendly and helpful personality. Everybody who came into contact with Dr. Stern was impressed by his high ideals, his devotion to the cause of science and his unfailingly deep interest in social and human relationships.

H. Mark

Mr. Horatio Ballantyne

Horatio Ballantyne, who died on January 25 at his home at Tadworth, Surrey, in his eighty-fifth year, was a consulting chemist and expert witness in patent cases whose theoretical knowledge was firmly buttressed by wide practical experience. His transfer from this field of activity to the Board of Lever Bros. in 1928, while at the height of his powers, though doubtless of benefit to commerce and industry generally and to that great Company in particular, left a gap in the ranks of scientific witnesses, and when, a few years later, his boyhood friend, Sir Dugald Clerk, the patent agent and expert on internal combustion engines and gaseous fuels, passed away, the fundamental contribution which they had made to the administration of the patent law was demonstrably evident. In engineering matters, Sir James Swinburne, the late Mr. H. A. Gill and Horatio's younger brother, the late Mr. W. H. Ballantyne,

provided an adequate complement; but their gallant efforts to assist in cases arising in other scientific fields only made it more manifest that the day of the comprehensive scientific expert witness had come to an end.

The Reports of Patent Cases bears witness to Ballantyne's amazing versatility. From his début in the famous Welsbach gas mantle litigation, he assumed the burden of scientific exposition in patent cases for more than thirty years, dealing with topics as diverse as gramophones, electric lamps and filaments, steel ball grinders, coal-cutting machines, typewriters, confectionery, the drying of milk and a host of others. The first encomium he received was in his first case and came from Mr. Justice Wills, who said in his judgment: "I wish to add that Mr. Ballantyne has given me reason to rely on him. He is one of the most truthful and fairest minded men I have seen in the witness box". The last to my knowledge appears in an appreciation by Sir Kenneth Swan, a distinguished leader of the Patent Bar and himself a son of a great inventor. He wrote: "His evidence, invariably characterized by scrupulous candour and fairness, was not only backed by profound technical knowledge, but was always based on a careful and crucial experiment; moreover it was given with that degree of precision and tenacity that rendered it proof against the most penetrating cross-examination. In short, he was a pattern of what an expert witness should be". Both, it will be noted, remarked Ballantyne's candour and fair-mindedness, two attributes which the experienced judge will thankfully recognize, and without which the most profound scientific knowledge will fail to impress. The value of an expert witness resides in the weight attached to the expression of his opinions. He must, of course, be technically competent and preferably free from addiction to technical jargon. But in the ultimate result, his assistance in the administration of justice will depend not only upon his perception and expression of truth, but upon the manner in which he completes and isolates it. In this Ballantyne was pre-eminent, and that explains why it was that, in cases involving scientific questions with which he was only generally familiar, his assistance was often more valuable than the evidence of more specialized experts.

Horatio Ballantyne was born at Glasgow in 1871. His father, Thomas Ballantyne, who was a pioneer of unitarianism in Glasgow, was married twice, and had thirteen children, Horatio being the eldest son and first child of the second marriage. His father died when Ballantyne was fifteen years old.

At fourteen he left school to begin work in the laboratory of Robert Tatlock, city analyst for Glasgow. It had been planned that he should go to the University, having gained a bursary that would have enabled him to do so, but the young Ballantyne resigned the bursary and went to Tatlock's, starting at a wage of 2*s*. per week.

It was a very busy commercial laboratory, with a large Students' Department attached, and gave a really extensive training in industrial chemical analysis. After some time Ballantyne became chief assistant, and Tatlock and his partner Thompson invited him to become, in 1898, a member of the firm when Dr. J. B. Readman was due to retire; but brighter prospects came his way.

During the years with Tatlock, he had opportunities for carrying on research, especially into the little-understood chemistry of the oils and fats. Some accounts of these investigations were published in the *Journal of the Society of Chemical Industry*. In the evenings he attended classes in chemistry, mineralogy, German, etc. He took first place in Great Britain in the 'South Kensington' examination in honours chemistry, and the first place also (with medal) in the Society of Arts examination in German.

In March 1896 occurred an event which determined the course of his professional life. A few years before that date, Tatlock had received from Norway some samples of minerals which were to be tested for what was then known as the "rare earths", especially yttrium, cerium, lanthanum and thorium oxides. The invention of the incandescent gas mantle by Auer von Welsbach had given a special value to such earths, the chemistry of which was quite unknown to chemists in general. Tatlock had passed on to Ballantyne the problem of working out methods of analysis, etc., and he became in a small way a specialist in this recondite subject.

The Welsbach Incandescent Gas Light Co. of London acquired the rights to the British Welsbach patents, and by the year 1895 had become so successful that many infringing manufacturers appeared. An action for infringement of patent was brought against one of them. Towards the end of October 1895 a specimen of the infringing article was sent to Tatlock for analysis, and as it was said to be made of the rare earths he handed over the problem to Ballantyne. In March 1896 Ballantyne was asked unexpectedly to proceed immediately to London to be present at the trial of the action. The case began before Mr. Justice Wills. Fortunately for Ballantyne, it turned out to be the most important case of the time. The principal leaders of the Patent Bar were engaged in it, as were the leading expert witnesses (Sir Henry Roscoe, Prof. (Sir) James Dewar, Dr. Otto Hehner, (Sir) James Swinburne, Dr. Dupre, (Sir) Dugald Clerk, John Murrey, Prof. Vivian B. Lewes, Prof. Lambert, etc.). Leading counsel for the patentee was J. Fletcher Moulton (afterwards Lord Moulton), at that time the most distinguished counsel at the Patent Bar. The trial of the action was very protracted. Most of the work on the controversial matters fell upon Ballantyne's shoulders and he worked feverishly, night and day. Three times he was called to the witness-box. Such was the event which began Ballantyne's career as an expert witness and led him to specialize in patents and cognate matters.

Ballantyne was elected vice-president of the Institute of Chemistry in 1918, and again for the years 1920–22. He served on a number of Board of Trade departmental committees dealing with patent law and practice and with inventions made in government service. He married in 1899 Miss K. Russell, who survives him with the three daughters of the marriage.

G. H. Lloyd-Jacob

Mr. D. B. Waters

David Bowe Waters, whose death occurred on February 7 at Glasgow at the age of forty-three, was a civil engineer and was responsible during the Second World War for much of the detailed technical development at the Road Research Laboratory (Department of Scientific and Industrial Research) of the devices known as 'plastic armour' and 'plastic protective plating': these materials were used on most of the Allied merchant ships for the protection of vital parts

from aircraft cannon fire. 'Plastic armour' consisted of a tightly packed mass of stone particles held together by a bituminous mortar and backed by a steel plate; 'plastic protective plating' was an even denser material with a higher stone content compacted by vibration and encased in thin sheet steel. In essence, these devices provided a protective layer, the resistance of which to penetration was highly irregular, thus causing projectiles to yaw away from a straight path.

Mr. Waters joined the Bituminous Section of the Road Research Laboratory in 1936: at the time of his death he was in charge of the Laboratory's Scottish branch at East Kilbride. His colleagues will long remember his originality of mind, enlivened always by gaiety and wit.

Dr. Ernst Wanner

Dr. Ernst Wanner was born in Zurich on July 22, 1900. In 1925, he was awarded the degree of doctor of mathematics at Zurich for work on groups of linear transformations, and in 1928 was appointed to the Swiss Meteorological Service, where he remained until his death from a heart attack on November 4, 1955.

He worked on magnetic variations at Regensberg and on seismology at Zurich. Latterly he was vice-director of the Swiss Meteorological Service and responsible for personnel. That he was successful in both these fields is a tribute to him both as a scientist and as a man. He was basically good-natured, modest and very straightforward.

With A. Kreis, Wanner constructed a 1,000-kgm. vertical seismograph, which assisted him in obtaining data for the study of Swiss earthquakes and their impact on Alpine structure. He also studied Swiss earthquakes historically, compiling a catalogue of shocks between the dates 1856 and 1879. With all this material he was able to work out the correlation between earthquake epicentres in Switzerland and Swiss Tertiary volcanics and thermal springs. He used a method due to G. Polya and F. Eggenberger on the coupling of earthquake aftershocks. Finally, with P. L. Mercanton, Wanner studied the magnetic anomaly in Jorat, near Lausanne.

Wanner was president of the Swiss Committee of the International Union of Geodesy and Geophysics, vice-president of the International Association of Seismology and the Physics of the Earth's Interior, and the Swiss representative on the European Seismological Commission. He was unmarried.

Ernest Tillotson

NEW FELLOWS OF THE ROYAL SOCIETY

At the meeting of the Royal Society on March 15, the following were elected to fellowship:

Dr. N. P. Allen, superintendent, Metallurgy Division, National Physical Laboratory, Teddington, Middlesex, distinguished for his work on alloy steels, their transformations, and their engineering properties

Prof. J. F. Baker, professor of mechanical sciences, University of Cambridge, distinguished both for his experimental and theoretical investigations of steel structures and for services to education in engineering.

Prof. R. M. Barrer, professor of chemistry, Imperial College of Science and Technology, London, distinguished for his work on the mechanism of adsorption and diffusion of gases in solids and the problem of molecular sieves in zeolite minerals.

Dr. R. Brown, head of the Agricultural Research Council Unit of Plant Cell Physiology, Oxford, distinguished for his work on germination of parasitic seeds and isolation of germination hormones, also for studies of factors involved in cell division and development.

Prof. J. A. V. Butler, professor of physical chemistry, University of London, distinguished for his work on thermodynamics, and the application of physical techniques for the solution of problems of molecular structure of deoxyribonucleic acids.

Dr. D. Gabor, Mullard reader in electronics, Imperial College of Science and Technology, London, distinguished for his work on transient electric phenomena, electron microscopy, the theory of communication and the electric arc plasma.

Dr. H. Grüneberg, reader in genetics, University of London, distinguished for his investigations into the expression of genes during development in mammals.

Dr. C. S. Hallpike, director, Otological Research Unit of the Medical Research Council, London, distinguished for his investigations of the physiology and pathology of the internal ear and the mechanisms of hearing and equilibration.

Prof. J. E. Harris, professor of zoology, University of Bristol, distinguished for his researches in several branches of experimental zoology.

W. K. Hayman, reader in analysis, University of Exeter, distinguished for his contributions to the theory of functions of a complex variable.

Prof. N. Kemmer, Tait professor of natural philosophy, University of Edinburgh, distinguished for his pioneering work on the fundamental particles of physics, particularly on the meson and its role in determining forces within the atomic nucleus.

Dr. N. Kurti, lecturer and demonstrator in physics, University of Oxford, and Senior Research Fellow, Brasenose College, distinguished for his work on phenomena at very low temperatures, particularly in paramagnetism and nuclear alignment.

Dr. R. G. MacFarlane, Radcliffe lecturer in hæmatology, University of Oxford, distinguished for his studies on blood coagulation and their application for the treatment of hæmophilia.

Dr. R. Markham, principal scientific officer, Plant Virus Research Unit (Agricultural Research Council), Cambridge, distinguished for his studies on plant viruses and for his contributions to knowledge of nucleic acids.

Dr. J. W. Mitchell, reader in physics, University of Bristol, distinguished for his work on the action of light on crystals, particularly in photographic emulsions, and on the nature of the photographic latent image.

Prof. W. D. M. Paton, professor of pharmacology, Royal College of Surgeons, London, distinguished for his work on the relation between chemical structure and pharmacological action, and for the discovery of several important new drugs.

Dr. A. B. Pippard, lecturer in physics, University of Cambridge, distinguished for his work on the electrical properties of metals at radio-frequencies, and for his studies of the superconducting state.

Dr. Helen K. Porter, principal scientific officer, Research Institute of Plant Physiology, Imperial College of Science and Technology, London, distinguished for her work on fructosans of leaves, on carbohydrate metabolism of fruits and cereals and for enzymological studies on polysaccharide syntheses in plants.

Dr. G. Salt, lecturer in zoology, University of Cambridge, distinguished for his experimental and ecological researches on insects, especially on parasitic Hymenoptera.

Prof. C. W. Shoppee, professor of chemistry, University College, Swansea, distinguished for his contributions to organic chemistry with special reference to the elucidation of problems of stereochemical relationships in the steroid field.

Prof. F. W. Shotton, professor of geology, University of Birmingham, distinguished for his contributions in stratigraphy and particularly for his work on the Pleistocene deposits of the Midlands.

Dr. E. I. White, keeper of geology, British Museum (Natural History), London, distinguished for his research on the earliest vertebrates and fossil fishes, particularly those from the Old Red Sandstone.

Dr. M. V. Wilkes, director, University Mathematical Laboratory, Cambridge, distinguished for his contribution to the design and construction of automatic calculating machines, and their application to the solution of a wide variety of scientific problems.

Dr. D. H. Wilkinson, lecturer in physics, University of Cambridge, distinguished for his researches in nuclear physics, especially his investigation of the properties of the energy levels of light nuclei.

Prof. A. Wormall, professor of chemistry and biochemistry, St. Bartholomew's Hospital Medical College, London, distinguished for his researches in biochemistry and for his pioneer work in the development of the use of isotopes in immunochemistry.

NEWS and VIEWS

Physical Metallurgy at the Imperial College, London: Mr. J. G. Ball

Mr. J. G. Ball, of the Atomic Energy Research Establishment, has been appointed to the chair of physical metallurgy in the Imperial College of Science and Technology, University of London. After leaving the University of Birmingham, Mr. Ball joined the Welding Research Council in 1941. When this became the British Welding Research Association in 1945, he was appointed senior metallurgist with responsibility for establishing and directing the metallurgical laboratories; there he initiated a programme of basic work on light alloy and structural steel welding. Mr. Ball led a strong team on steel welding which has made fundamental contributions to the understanding of welding behaviour and the development of new alloy steels of good weldability. He was particularly associated with developments in the fabrication of Bailey bridges and is a member of a Ministry of Supply Committee on this subject. He joined the Atomic Energy Research Establishment, Harwell, in 1949, to take charge of investigations on the metallurgy of plutonium, and he pioneered the special techniques for handling plutonium and for micro-scale investigations. He was jointly responsible with Dr. R. Hurst for the design of the new plutonium laboratory at Harwell, which is based on new principles and incorporates novel techniques. The plutonium core for the fast reactor Zephyr was fabricated under his direction. For the past three years he has been head of the Reactor Metallurgy Group in the Metallurgy Division, and has given much attention to the problems of irradiation behaviour of fissile materials and the design and behaviour of fuel elements. Mr. Ball is a member of the Council of the Institution of Metallurgists. With Mr. Ball's appointment, it is intended that the development of the research and postgraduate activities in metallurgy at the Imperial College will have a bias towards the metallurgy of nuclear energy.

Chemistry at Rothamsted Experimental Station: Dr. G. W. Cooke

Dr. G. W. Cooke has been appointed head of the Chemistry Department of Rothamsted Experimental Station, in succession to Dr. R. K. Schofield, who has gone to the Department of Agriculture, University of Oxford (*Nature*, **176**, 910; 1955). Dr. Cooke was educated at Loughborough Grammar School and (the then) University College, Nottingham, graduating with first-class honours in chemistry in 1937. After postgraduate research in biochemistry with the late Prof. J. M. Gulland, he joined the Chemistry Department at Rothamsted as a Ministry of Agriculture research scholar. In 1940 Dr. Cooke obtained his Ph.D. for a thesis on soil phosphate chemistry. During the Second World War he was concerned with testing new phosphate fertilizers which were made as alternatives to superphosphate. Afterwards he turned his attention to improving the efficiency of fertilizers by developing special methods of application. This work, which proved the value of fertilizer placement practices for certain crops, is already being applied by farmers. His experience in fertilizers has led to Dr. Cooke being invited to carry out short-term work for both the Food and Agriculture Organization and the Organization for European Economic Co-operation. He has been honorary secretary of the Agriculture Group of the Society of Chemical Industry, of which he is at present vice-chairman. He has also served on the Council of the Fertilizer Society.

Symbol for the International Geophysical Year

It has been decided to use the following symbols in connexion with the International Geophysical Year:

(1)

(2)

Symbol 1 is a representation of the Earth with meridians and circles of latitude, showing the south pole, to signify the special antarctic features of the International Geophysical Year; part of the Earth is shown in darkness, implying the influence of the Sun; a satellite orbit is shown encircling the Earth at an inclination to the equator, with the satellite, of course exaggerated in size, shown partly sunlit. Symbol 1 is to be used without change on publications issued by the Comité Spécial de l'Année Géophysique Internationale (CSAGI) and other International Geophysical Year publications under rules issued by the General Secretary of the Comité Spécial. This symbol does not include an inscription because the relevant information will normally be printed on the title page and cover of each publication. Symbol 2 is to be used on instruments, equipment or uniforms of personnel associated with the International Geophysical Year national committees, where the French or English language is appropriate; other national committees will substitute a translation of the inscription in the relevant language. If commemorative postage stamps are to be issued by any nation, the inscription may be used with the central symbol but otherwise disposed and with a border other than the octagonal one.

Man-power in the Royal Air Force

In submitting the Air Estimates to the House of Commons on March 5, the Secretary of State for Air, Mr. Nigel Birch, referred at some length to the problem of saving man-power. Apart from limited inquiries into specific aspects of the subject, in which the Royal Air Force has had the assistance of business men, trade union officials and others, imaginative and effective work is going on all the time in the Royal Air Force itself, which has, he claimed, pioneered the application of scientific methods to the man-power question. This work has aimed not only at saving man-power but also at adjusting establishments in a highly technical and rapidly changing Service; further, the Air Ministry Man-power Research Unit has been in existence for many years and has done much good work. Inquiries are now being extended into the whole life and work of a station, and not only into specific aspects. For example, it has been found that in servicing operational aircraft, with a slightly larger supervising staff and tradesmen with the correct skills, considerable savings in man-power can be effected. Arising out of the discovery of a desire to have the technical and administrative wings on the airfield broken down into squadrons, experiments are being made with technical squadrons, signal squadrons, engineering squadrons, and so on, which have indicated that morale as well as efficiency are thereby improved. The application of these conclusions in a much bigger way on operational airfields is now being investigated by the Man-power Utilization Committee. Senior staff are also being sent to make special studies of work methods, not only in the Royal Air Force, but also in industry, and in this work they are having the help of young national service officers with honours degrees in scientific subjects, who were helping to work out the techniques.

Mr. Birch believes that the experience drawn from industry can have solid and substantial results in saving man-power and increasing efficiency, and that as a result of all these experiments it should be possible during the next two or three years to save some thousands of posts. He referred also to the need for very highly trained technical officers which is being met by the Technical Cadet Scheme, and by the postgraduate training of serving officers, for example, in the postgraduate course in guided weapons. The real background of the Royal Air Force was, and will remain, however, the general duties officer, and the period of training at Cranwell has been extended to three years, first to enable the cadets to finish their training in jet aircraft, and second, to ensure that they have a good general education as well as a technical one.

Mr. G. S. de Freitas, while welcoming this reference to scientific research into man-power, and referring to the need for increasing the supply of scientists and technologists, as well as reducing unnecessary demands on the limited resources in Britain of skill and materials, suggested that more attention to human relations in the Royal Air Force is also required. There was little other reference in the debate to what is already being done in the Royal Air Force to save man-power, although there was general recognition of the importance of deploying wisely scientific and technological man-power and increasing its supply so far as possible. Dr. A. D. D. Broughton, in supporting the idea of an exchange of technicians between the Service and industry, stressed the importance of keeping a careful watch on the competition for technical man-power between the Services and industry.

Recent Earthquakes in Lebanon

A swarm of earthquake shocks, of which four were strong, occurred on the night of March 16, and the following day. The epicentres were in the south of Lebanon, where considerable damage was done in some forty villages. Reports so far received state that 112 people are known to have been killed and more than a hundred injured. Considerable apprehension was caused, and thousands of people gathered on the shore, away from buildings. Minor earth tremors have been known to occur in Lebanon, but large shocks are infrequent there. The larger earthquakes are more frequent in southern Turkey.

Preparation of Illustrations for Publication

Illustrations in the form of drawings or graphs are often the most important feature of a scientific paper, and many research workers with little or no previous experience in the matter sometimes unwittingly cause considerable extra trouble and expense in editorial offices by submitting illustrations which require a great deal of alteration before they are suitable for reproduction. Most journals have their own peculiarities, and before submission of a paper intending authors should examine the particular journal they have in mind to see, for example, if any particular form and size of lettering is favoured (many journals prefer to set up letters and numbers in actual type when these occur outside the block).

However, as a general guide, intending authors (even senior ones) could not do better than consult "Notes on Preparation of Illustrations", prepared by the editorial office of the *Biochemical Journal* (price 1*s.*, from the Lister Institute of Preventive Medicine, Chelsea Bridge Road, London, S.W.1). This gives simple instructions, and goes on to consider a typical graph. It shows the graph drawn incorrectly, then as it should have been drawn, and finally as it would appear when published. The points discussed are really based on common sense alone; but the pamphlet does emphasize in a particularly direct way the essentials of the matter, and its acquisition by departments and/or individuals for the modest outlay of a shilling is a worth-while investment.

Stress Analysis Group of the Institute of Physics: Annual Conference

THE summarized proceedings of the ninth annual conference of the Stress Analysis Group of the Institute of Physics, which was held in the University of Sheffield during September 28–30, are printed in the January issue of the *British Journal of Applied Physics* (7, 1; 1956). The opening lecture was delivered by D. G. Sopwith (Mechanical Engineering Research Laboratory, East Kilbride), who spoke on the application of stress analysis to the design of some engineering components. Dr. Sopwith outlined the pattern that any design investigation should follow and emphasized that the stress analyst's task is not finished until the results are presented in a form such that the designer can apply them directly to the particular problem under consideration. Four papers by members of the Engineering Department of the University of Sheffield dealt with the measurement of residual stresses in cold-drawn tubes; the effect of tensile overstrain on the yield criterion for mild steel, brass and copper; extrusion under drop-hammer impact; and stress-strain characteristics of metal at high rates of strain, respectively. D. A. Drew (Rolls-Royce, Ltd., Derby) discussed the measurement of aircraft engine vibration in flight and pointed out that, though great accuracy is not vital, the measuring system has to be capable of dealing with frequencies up to 15 kc./s. Other papers dealt with strain gauges; the use of the resistance-network analogue for solving plane stress problems; machining stresses in turbine blades; and the application of the frozen stress method of photo-elastic analysis using 'Araldite' resin models to the study of the stresses in the T-junction of a branched pipe. In addition, a series of short papers presented by R. G. Boiten (Institut T.N.O. voor Werktuigkundige Constructies, Delft), describing the work of his organization, are of particular interest; they included descriptions of the photoelastic bench at Delft, work on prefabricated strain gauges, and a new type of brittle lacquer the raw material of which consists of plumber's resin.

Refugia Indicated by Pollen Profiles

C. H. HEUSSER has given an account of some interesting pollen profiles in the Queen Charlotte Islands, British Columbia (*Canadian J. Bot.*, **33**, 5, 429; 1955). In all, five peat sections were examined from muskegs in different islands of the group with the primary purpose of reconstructing the post-glacial plant succession and associated climatic and physiographical alterations. A secondary purpose was to support or disprove the geological and zoological data favouring the existence of refugia in which biota survived from pre-glacial or inter-glacial times. The oldest pollen record tends to support this contention. The record is older than any derived from sections heretofore studied on the north-west coast. Twenty-three plant entities are represented in the bottom sediments below the lodgepole pine maximum which in these other sections marks the oldest peat. In addition, 27 per cent of the coniferous pollen at the base of the section is constituted of climax forest trees, thus implying the presence of long-established forest when pollen sedimentation began. The number and kinds of pollen in the basal peat favour the interpretation that vegetation persisted in refugia through at least the last glaciation. The pollen profiles further corroborate earlier findings for changes in land–sea level relations and for the following post-glacial climatic sequence: early cool-moist, warmer and drier (thermal maximum), and late cooler and wetter.

The Neurohypophysis: Symposium in Bristol

THE Colston Research Society, Bristol, has arranged since 1948 annual symposia on subjects appropriate to each of the Faculties in turn of the University of Bristol, and this year the symposium, to be held during April 9–12, will be on "The Neurohypophysis". The subject is one which appeals to a diversity of scientific interests, and the list of invited speakers includes anatomists, biochemists, pharmacologists, physiologists and zoologists. Besides eight speakers from Great Britain, there are three speakers from the United States, two from Sweden and one each from Canada, Chile, France, Germany and Switzerland. The symposium will be under the direction of Prof. H. Heller (Department of Pharmacology, University of Bristol), and Sir Henry Dale will open the proceedings. On April 10 the Society will hold its annual reception, at which the principal speaker will be Sir Lionel Whitby. Further information can be obtained from Dr. R. J. Fitzpatrick, Department of Pharmacology, University of Bristol.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: E. W. Momber (assistant director of agriculture, Northern Region, Nigeria), deputy director of agriculture, Northern Region, Nigeria; T. A. Phillips (principal of the School of Agriculture, Northern Region, Nigeria), deputy director of agriculture, Eastern Region, Nigeria; S. T. Hoyle (principal scientific officer, Nyasaland), senior principal scientific officer, Nyasaland; Miss F. M. Roberts (principal scientific officer, Jamaica), principal scientific officer, plant pathologist, Kenya; W. H. Foster, senior scientific officer (botanist and plant breeder), Northern Region, Nigeria; A. M. M. McFarquar, agricultural economist, Western Region, Nigeria; P. Thomas, cocoa soil survey officer, Gold Coast; D. R. Younger, manager, Yumdum Experimental Farm, Gambia; C. F. Hutchison, assistant bacteriologist, Jamaica; J. E. Clarke, entomologist, Game and Tsetse Control, Northern Rhodesia; D. G. Coursey, scientific officer (chemist), Federation of Nigeria; M. G. R. Hart, scientific officer, Sierra Leone; D. W. Brocklesby, veterinary research officer (protozoologist), East Africa High Commission; R. I. C. Hyam, veterinary officer, Northern Rhodesia; W. R. Nunn and L. D. Tennant, veterinary officers, Uganda; D. J. Skinner, veterinary officer, Kenya; Miss M. de Vere Allen, laboratory technologist, Kenya.

Announcements

Brigadier J. A. Sinton, V.C., F.R.S., has been awarded the Manson Medal for 1956 of the Royal Society of Tropical Medicine and Hygiene. This Medal is awarded triennially to the living author of such original work in any branch of tropical medicine or tropical hygiene as the Council may consider to be deserving of the honour.

Mr. P. R. Owen, reader and director of the Laboratory of Fluid Motion in the University of Manchester, has been appointed professor of the mechanics of fluid motion in the University.

Mr. R. W. Marsh, head of the Plant Pathology Section at Long Ashton Research Station, is being seconded to the Food and Agriculture Organization for the period April–June to report on crop protection methods and organization in Yugoslavia.

A conference on starch will be held in Detmold, Germany, during May 2–4, and will consist of three sessions as follows: fundamental research and research methods; starch production and techniques; and starch fractions and derivatives. The conference is organized by the Arbeitsgemeinschaft Getreidesforschung e.V., Detmold, from which further information can be obtained.

Following the extremely successful Summer School in Theoretical Chemistry held last year at Oxford, another similar School is to take place during July 7–21, under the direction of Prof. C. A. Coulson. Further particulars can be obtained from the Assistant Secretary, Delegacy for Extra-Mural Studies, Rewley House, Wellington Square, Oxford. Applications should be made before April 30.

The Chemical Society is organizing a symposium on "Antibiotics and Mould Metabolites", to be held on March 26 in the Great Hall, University of Nottingham. Seven papers will be read and these will be published later as No. 5 in the Society's series of "Special Publications" (8*s*. 6*d*. to Fellows of the Society; 15*s*. to others). Further information can be obtained from the Society at Burlington House, Piccadilly, London, W.1.

The Society of Chemical Industry is organizing a three-day conference on the "Disposal of Industrial Waste Materials", to be held in the University of Sheffield during April 17–19. The conference will cover a very wide range of materials, including fine chemicals, industrial effluents, slag and ash, and atomic-energy products. The conference is open to all on payment of a registration fee of 2 guineas (10*s*. 6*d*. for members of the Society). Application forms and further information can be obtained from the General Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

A symposium on "Vegetable Tannins", organized by the Society of Leather Trades' Chemists, will be held in the Chemistry School, Pembroke Street, Cambridge, during April 12–13. The chairmen during the two days will be Prof. R. D. Haworth and Dr. F. E. King, respectively. The conference is open to all, on payment of a fee of £1. Registration forms, to be returned by March 31, and further information can be obtained from G. H. W. Humphreys, Forestal Land, Timber and Railways Co., Ltd., Forestal Central Laboratories, Harpenden, Herts.

An international symposium on "Macromolecular Chemistry", under the auspices of the Commission on Macromolecules of the International Union of Pure and Applied Science, will be held in the Weizmann Institute of Science, Rehovot, Israel, during April 3–9. The first half of the symposium will consist of sessions of papers on the following three topics: general behaviour of polymers in solution; general behaviour of biocolloids and polyelectrolytes in aqueous solution; and special polymeric systems in solution. The rest of the meeting will be devoted to tours around Tel Aviv, Haifa and Jerusalem. Further information can be obtained from the Weizmann Institute of Science, Rehovot.

The fourth and final meeting of the series of meetings on "Nutritional Requirements and Food Fortification", organized by the Nutrition Panel of the Food Group, Society of Chemical Industry, will be held at the Royal Society of Medicine (Barnes Hall), 1 Wimpole Street, London, W.1, on April 11, at 6 p.m., when the subject of iodine and fluorine will be discussed. Iodine metabolism and the iodization of food will first be considered, and the meeting will then turn to physiological and medical aspects of fluorine, including the dental problem and the fluoridation of water supplies. Further information can be obtained from the honorary secretary of the Panel, L. C. Dutton, Virol, Ltd., Hanger Lane, Ealing, London, W.5.

A debate on the motion "That Science can Provide as Good an Education as the Humanities", organized by the Fine Chemicals Group of the Society of Chemical Industry, will be held in the William Beveridge Hall, Senate House, University of London, at 7 p.m., on April 20. The principal speakers will be as follows. *For the Motion:* Dr. R. P. Linstead (rector of the Imperial College of Science and Technology, London) and Prof. A. R. Ubbelohde (professor of thermodynamics in the Imperial College). *Against the Motion:* Mr. B. L. Hallward (vice-chancellor of the University of Nottingham) and Mr. H. D. P. Lee (headmaster of Winchester College). The chair will be taken by Sir William Ogg (director of the Rothamsted Experimental Station and immediate past-president of the Society of Chemical Industry). Admission will be by ticket, obtainable from the honorary secretary of the Group, Dr. J. D. Kendall, Ilford, Ltd., Ilford, Essex.

The essay subjects for this year's *Endeavour* Prizes of the British Association for the Advancement of Science will be as follows: research in polar regions; scientific aids to archæology; the story of steel-making; the chemistry of big molecules; new elementary particles; the control of plant diseases. The essays must be sent in by June 1 and should not exceed four thousand words. Competitors must be less than twenty-five years old, and the Prizes will be 50, 25 and 15 guineas, respectively, with two special awards of 5 guineas to those less than eighteen. Further information can be obtained from the Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

Erratum.—In the biographical note on Edward Goodrich Acheson in the issue of March 3, p. 412, the United States Patent Office was incorrectly referred to as the United States Post Office; the Patent Office exhibited one of E. G. Acheson's patents, among seventeen which were considered to have most benefited mankind, and not seventeen of Acheson's patents, as stated.

SNOW ACCUMULATION AND ABLATION

THE mass of snow and ice stored at high elevations on the Earth is a large reservoir of the hydrological cycle. Any reduction in its mass by melting releases potential energy, and the debts of past climates become discharged. We have neither made much use of this energy nor made a serious attempt to measure its size or its fluctuations. Even the mass of water accumulated in annual snowfields is measured only in a few places, and yet its sudden release in a thaw is often the source of a disastrous flood; for example, the 1950 Red River flood at Winnipeg. If the snow stored in the upper catchment area of the River Severn were known and the relation between its ablation and the weather were established, it would be possible to predict the likelihood and the size of the flood lower down the river. Unfortunately, however, snow accumulation and ablation are not easy to measure, and we have almost no knowledge of the quantity of water lying as snow in any catchment area in Britain.

The discussion meeting on "Snow Accumulation and Ablation", organized jointly by the Royal Meteorological Society and the British Glaciological Society and held in London on January 18, was concerned mainly with the problem as it affects the budget of glaciers. Even in Britain, glaciers are of interest; for as one speaker (L. C. W. Bonacina) remarked, there would be glaciers in Scotland after fifty summers—not winters—like that of 1951.

It is well known that European glaciers are retreating in association with the warming of the climate. Their retreat is measured in the simplest way by recording the annual change in the position of the glacier tongue. This measurement merely indicates that the glacier is striving to balance its income, the total accumulation, against its expenditure, the net ablation; but it reveals neither the sizes of its budgetary items, nor which climatic variable dominates its retreat. For that purpose it is necessary to measure the annual changes in the glacier mass both in the higher parts where there is a surplus (the net accumulation) and at the lower levels where there is a deficiency (the net ablation). This will show whether the retreat is associated with decreased precipitation or with increased atmospheric heat causing greater ablation. Then it is necessary to investigate the heat balance at the glacier surface to discover the importance of the various meteorological factors causing the ablation. All the heat sources and sinks at the glacier surface have to be measured: the net radiation, the convection from the air, the conduction from the glacier, the evaporation and the condensation. This task is similar to estimating the heat balance at the ground surface, with the one simplification that the snow surface remains at 0° C. whenever melting occurs.

Such investigations of the mass and heat budget of a glacier are difficult undertakings, and it is not surprising that only a few studies have been made. The observations of Ahlmann and Eriksson in North East Land in 1931 were analysed by Ångström[1]. An intensive study of the heat balance over a glacier surface was made by Sverdrup[2–4], Ahlmann and Olsson on Isachsen's Plateau in Spitsbergen in 1934. Sverdrup's findings were used to obtain some idea of the relation between ablation and climate on the Vatnajökull in Iceland by Ahlmann and Thorarinsson[5], and these findings were also applied to observations on the Fröya Glacier in East Greenland by Eriksson[6]. The most exhaustive study has been made by Wallén[7] on the small, but accessible, Kårsa Glacier in Swedish Lapland. This is the only study that has covered a number of consecutive years (1942–48), and it was concluded that the principal cause of the recession of the glacier was increased ablation associated with increased summer temperature and humidity, and a longer ablation season. More recently, Baird[8], Ward[9] and Orvig[10] have made the first studies in the Canadian Arctic on two ice caps in Baffin Island, and observations have been made on the ice shelf of Queen Maud Land in the Antarctic[11]. (An ice shelf is a coastwise glacier composed of land ice, sea ice and local snow, generally floating on the sea.)

The discussion at the meeting was opened by R. A. Hamilton, of the British North Greenland Expedition, who gave a brief description of the geography and glaciology of the Greenland ice cap and of its dominant weather systems.

H. Lister, another member of the Expedition, followed with a detailed account of his measurements of the ablation and of the heat balance during the melting season made on one of the glaciers flowing from the Greenland ice cap. The practical difficulties of using normal meteorological instruments to measure the gradients of temperature, vapour pressure and wind speed over a polar glacier surface were well illustrated. The many meteorologists present must have been convinced of the need for the development of more suitable instruments for reliable work in cold climates. The subject of heat transport through the air has been one of much controversy during recent years in the light of current ideas on turbulence, and there is a feeling that the Greenland ice cap is not a convenient place to delve into detailed research on this problem; it can be pursued more profitably on the snowfields of the Cairngorms, for example. Such a site would be suitable also for development trials of instruments and for determining the optimum observations required for a study of heat balance. It is gratifying to record that P. D. Baird, of the University of Aberdeen, has made a start in this direction, with the help of the Meteorological Office, by establishing a weather station on the Cairngorm plateau this winter.

W. H. Ward spoke generally of the problems of the direct measurement of snow accumulation and ablation in the light of his experiences on two ice caps in Baffin Island, Canada. The long-term seasonal measurement of accumulation and ablation was not too difficult and was easiest in the ablation zone of a glacier. It was a question of measuring the change in the mass of water relative to a suitable reference horizon, and the dense ice surface in the ablation zone was a convenient reference. But in the thick permeable accumulation zone it was sometimes impracticable to reach a reference level through which some melt water did not seep and re-freeze at a lower level. When accumulation and ablation

occurred intermittently, it was difficult to define the duration of the ablation season.

Daily measurements of ablation and accumulation are of greater interest to the meteorologist, and the usual methods of measurement are subject to many errors. The ablation is frequently measured by the lowering of the surface relative to a stake sunk in the snow, and the change in level is multiplied by a density to give the ablation in, say, inches of water. But the surface can settle for a variety of reasons. Compaction can occur without ablation, melt water descending through subsurface snow can cause compaction beneath a frozen snow surface and radiation can cause melting below the surface. Furthermore, the snow density varies irregularly with depth. Constant watching of the snow and the weather cannot eliminate all sources of error. In the accumulation area of a glacier during the melting season, the total mass of ice and water can be measured by sampling every snow layer from a pit dug to a suitable reference level. The density of each sample and the thickness of each layer are measured and their products summed up. That task may easily take a full day's work. The water content of all the samples can be measured by calorimetry, but it is an impossible task in a deep profile.

These are the methods of measurement available at present, and there is a pressing need to develop a simple field-method of recording separately the total masses of water and ice in a melting snow profile.

W. H. Ward

[1] *Geog. Ann.*, **16**, 264 (1933).
[2] *Geog. Ann.*, **17**, 145 (1935).
[3] Chr. Michelsens Inst. for Videnskap og Åndsfrihet. Beretningar, **5**, 3 (1935).
[4] *Geofis. Pub.*, **11**, No. 7 (1936).
[5] *Geog. Ann.*, **20**, No. 3–4 (1938).
[6] *Geog. Ann.*, **24**, 23 (1942).
[7] *Geog. Ann.*, **30**, 451 (1948).
[8] *J. Glaciol.*, **2**, 2 (1952).
[9] *J. Glaciol.*, **2**, 158 (1953).
[10] *Geog. Ann.*, **36**, 193 (1954).
[11] *Weather*, **7**, 314 and 327 (1952).

TESTING OF METALS BY OPTICAL METHODS

On January 13 a symposium, at which there were some sixty participants, was held at the Institute of Physics, London, on "The Possible Uses of Surface Methods as a Means of Testing Metals (with Special Reference to Optical Methods)". This was sponsored by the Non-Destructive Testing Group of the Institute of Physics, and it was to be understood that only non-destructive methods were to be discussed. The symposium was opened by Prof. S. Tolansky, of the Royal Holloway College, University of London, Dr. O. S. Heavens, of the University of Reading, and Dr. R. W. B. Stephens, of the Imperial College of Science and Technology, University of London, who each in turn gave a half-hour discourse on selected topics, after which the meeting was thrown open to general discussion. The chair was occupied by Dr. J. Thewlis.

In an introductory survey, illustrated by some forty slides, Prof. Tolansky selected as typical subjects for examination some of his own studies on the optical testing of surface finish, of microtopography in general, the examination of micro-hardness and directional hardness, the character of electrodeposits and the examination of machined metal surfaces. Attention was devoted to five different methods of approach which he uses for the study of surface structure. There is first two-beam interferometry, which is capable of extensive application; then, for increased precision, indeed reaching down to structural features the heights of which approach crystal lattice dimensions, there is multiple-beam interferometry in a variety of forms, examples of which were shown. It was stressed that the great resolutions attainable are only in the height–depth dimension and not in extension across the surface. Experiments revealing the perfection of contour of the silver layers used in multiple-beam interferometry were described. The light-profile microscope was then illustrated, and it was emphasized that this has very obvious metallurgical applications, some of which were shown. The advantage of this system is that it is capable of resolving an elementary cube of side (roughly) half a light-wave. Thus in effect a useful magnification of about a thousand is available in three dimensions, and this is of much value in many problems. A simple optical shadow-casting technique was then described and possible applications discussed.

Finally, a review was included of a critical experimental examination intended to test the validity of the method of total reflexion advocated for the exploration of engineering bearing surfaces. In this, a hypotenuse of a right-angled prism is pressed on to the surface and at the points of contact total reflexion is interfered with, revealing thus a dark pattern. Some difficulties in interpretation were discussed.

Dr. Heavens then reviewed the development of recent studies of surface reflectivity and of the assessment of surface films and oxide films on metals. He pointed out that electromagnetic theory enables the optical constants of a material to be deduced from observations on light reflected from a surface. The theory is simple for the ideal theoretical case of a plane boundary separating homogeneous, isotropic regions. Thus accurate experiments can yield information on the nature of a real surface from the difference between such observations and the computations of the theory for the ideal case. In the case of transparent materials, the presence of a transition layer at the surface is revealed by a gradual, rather than abrupt, differential phase-change in the light reflected from the surface. For heavily absorbing materials, the optical constants are easily deduced from polarimetric observations. Since the depth of penetration in these cases is a small fraction of a light-wave, then these observations yield information about the surface layers only and cannot easily be adapted to the problem of examining the bulk properties. Simple criteria exist, however, enabling the homogeneity of the surface layers to be checked.

The problem of examining surface roughness was then discussed by Dr. Heavens. He indicated that this may be tackled by a number of different reflexion methods, according to the scale of the roughness involved. For very rough surfaces (irregularities of many wave-lengths) he described scattering methods as useful. By judicious selection of the wave-length a wide range of roughnesses may be covered. Irregularities of the order of a wave-length may be examined by two-beam interference methods, such as are widely used in the optical industry. Under this heading, the interference microscope, coupled with replica techniques, was mentioned. It was then stressed that for surface roughnesses much smaller

than a wave-length there are two notable methods, namely, multiple-beam interferometry which can be applied to a wide range of surfaces, both transparent and absorbing, and, for specialized applications, phase-contrast methods. Both these methods enable a very high resolution normal to the surface to be attained.

Although much information may be obtained by a detailed analysis of the state of light reflected from a surface, methods suitable for non-destructive testing tend to be restricted to those which are reasonably simple to make and to interpret.

The third formal contribution, by Dr. Stephens, was devoted mainly to suggesting future possible extensions of techniques. It was pointed out that, as a general assessment, the application of optical reflexion methods is mainly dependent on the provision of good reflecting surfaces. Since for opaque materials the light-wave penetrates only to depths of the order of a few hundred angstroms, considerable care is necessary to avoid any treatment of the surface which might alter appreciably its physical characteristics as compared with the bulk material. The use of obliquely incident light minimizes the effect of small surface blemishes, and radiation wave-length is another factor at our choice. In testing for a high surface polish, it would be desirable to use the shorter ultra-violet wave-lengths; but when the object is to standardize the material itself, then longer wave-lengths are to be preferred. Dr. Stephens then directed attention to the recent advances in infra-red detectors—the photoconductive cells with their very small time-constants which provide new possibilities in non-destructive testing. Moving farther along the electromagnetic spectrum to the microwave region, the use of these centimetre waves offers an advantage in reflectivity measurements from the aspect of less exacting requirements in surface smoothness, and furthermore, by changing the frequency, the effective depth of penetration can be conveniently varied. Dr. Stephens here emphasized the advantage of such studies over methods using visible light, which are confined effectively to surface layers.

Recent work on the fundamental properties of surface electromagnetic waves has indicated another possible line of approach to the investigation of surface properties. These, Sommerfeld or Zeeneck waves, are attenuated both in the direction of propagation and normally to the surface to an extent dependent on the reactance of the surface, and are thus sensitive to geometrical irregularities and surface composition. Another approach in surface testing which Dr. Stephens thinks may merit attention is to investigate optically the effect of applying a second physical agency to the specimen, for example, a magnetic field, as in the Kerr magneto-optic rotation effect.

The three formal surveys were succeeded by a lively discussion to which many of the audience contributed. An appreciable fraction of the available time was taken up with a discussion of the reliability of replication methods, contributions being made by Dr. J. Thewlis, Miss K. B. Day and also Prof. Tolansky, who expressed the view that he has experimentally established that some materials can be used for making replicates with very high fidelity in extension, but yet simultaneously with appreciable uncertainty in depth. Mr. J. C. Kelly raised the issue of the relative perfection of contour of vacuum-deposited silver and vacuum-deposited dielectric multilayers. This matter received appreciable discussion.

The novel surface-penetrating methods proposed by Dr. Stephens aroused much interest and several queries about such procedures were posed.

Several members present were surprised at the extreme sensitivity of the polarization methods advocated by Dr. Heavens.

It was clear from the vigour of the discussion that the symposium had justified itself and focused attention in a practical way on a wide variety of techniques available to those who must needs examine metals in a non-destructive fashion.

PHOSPHOLIPIDS IN FOODS

A CONFERENCE on recent advances in the knowledge and uses of phospholipids in foods, arranged jointly by the Food Group and the Oils and Fats Group of the Society of Chemical Industry, was held in London during February 9–10 at the Wellcome Research Institution. The opening session, under the chairmanship of Prof. T. P. Hilditch, was concerned with the chemistry and physical chemistry of phospholipids. Papers were presented by Prof. T. Malkin and Dr. B. A. Pethica. The afternoon session, at which Dr. K. A. Williams took the chair, was devoted to consideration of methods of separation. Dr. June Olley described methods of counter-current distribution, and Mr. D. N. Rhodes chromatography. A third paper, on deteriorative changes in food phospholipids, was presented by Dr. C. H. Lea. During the first half of the second day, two papers were presented: one by Dr. J. A. Lovern on phospholipids in fish, and the other by Dr. F. Aylward on plant phospholipids, the chairman being Dr. A. J. Amos. The final session, under the chairmanship of Prof. A. C. Frazer, was also introduced by two papers: Dr. J. N. Hawthorne spoke on animal phospholipids, and Mr. H. H. Hutt on the large-scale production and industrial uses of phospholipids.

The papers were full of interesting information and covered a wide range, from relatively abstruse and detailed chemistry and physical chemistry to technical points concerned with large-scale production. Discussion was lively and varied in each session. It was apparent that things are moving on the chemical side. A wider range of pure synthetic phospholipids is likely to be available in the near future. This should lead to greater and more accurate knowledge of the physical chemical properties of this group of substances. Once this information begins to become available, many fascinating problems in the biological field, especially those associated with the structure and functions of lipoproteins, are likely to open up. The importance of close co-operation between chemists, pharmacologists, biochemists and nutritionalists in this field cannot be over-emphasized.

Work on phospholipids in foods is still in a formative stage, but methods of isolation and identification are rapidly developing. The importance of phospholipids in relation to deteriorative changes in food is well recognized. They may also play an important part in relation to some of the attractive properties of foods that technologists may wish to retain or enhance. This conference concerned itself mainly with the chemical and physical chemical background, with the occurrence of phospholipid in natural

materials and the technological uses to which phospholipids may be put. There is clearly considerable scope for the use of phospholipids in food technology. However, the biological effects of separated and prepared phospholipids used in food out of their normal context will require careful examination. With increasing knowledge and improving techniques in this field, it should soon be possible to make a more accurate assessment of the importance of phospholipids in the diet to health and nutrition. We may confidently expect considerable advances in this field during the next ten years, and it is encouraging to see such a wide interest taken in the subject at this early stage.

FULBRIGHT PROGRAMME IN GREAT BRITAIN AND COLONIAL TERRITORIES

FIFTH REPORT

THE fifth annual report on the Fulbright Programme in Britain and Colonial Territories* takes the form of a review and appreciation of the work of the Commission during 1949–54. To this Senator J. W. Fulbright himself contributes a foreword, while there are reviews from the American side and from the British side by Herbert Agar and Dame Lillian Penson, respectively, an article on "Orientation" by Sir Alexander Gray describing what is done to introduce the newly arrived scholars, and a series of articles on special features of the Programme. Sir Raymond Priestley deals with the Colonial programme, Mrs. L. M. Cochrane with the "Special Categories", Dr. S. C. Roberts with the American Studies Conference and Dr. E. A. Ford with the Interchange of Teachers Programme. There are also the usual general appreciations of the work of the British scholars in America and of American scholars in Britain, this year by Dr. F. A. Young and Dr. A. L. Goodhart, respectively, followed by comments from selected lecturers, advanced research scholars, supervisors and graduate students. Besides a summary of awards since 1949, there are appended a directory of Fellows for 1949–54 and an analysis of fields of study and research during 1953–54.

Of the 674 awards in 1953–54, compared with 732 in 1952–53, 329 were to United States and 345 to British citizens, the 1952–53 figures being 349 and 383, respectively. Of those to United States citizens, twelve were to visiting lecturers to British universities, eighteen to advanced research scholars and 163 to graduate students; eleven awards were made in the special categories group; fourteen for visiting lecturers, research scholars, school teachers or graduate students in the British Colonial Territories, and a hundred travel grants were again made to primary and secondary school teachers for exchange under the Anglo-American Teacher Interchange, the remaining eleven awards being to lecturers for the American Studies Conference. The travel grants to British citizens likewise included one hundred to school teachers under the Anglo-American Teacher Interchange, seventy-eight to advanced research workers, visiting lecturers and teachers and 167 to graduate students. The anticipated 350 awards to United States citizens and 384 to British citizens in 1955–56 will bring the cumulative total since 1949 to 4,842. Analysed by fields of study and research, the subjects claiming most awards in 1953–54 were chemistry (26 British and 13 American), education (13 and 3), history (16 and 23), literature (16 and 44), mathematics (11 and 4), physics (12 and 6), medicine (20 and 2), engineering (23 British) and dentistry (12 British).

Originally, the prime concern was to place the scholars in the universities of the United Kingdom; but it was contemplated from the beginning that there should be a counterpart to the reception of American university teachers and students in British universities in the form of travel grants for British lecturers and students to go to the United States, and on both sides applications have always vastly exceeded the number of possible awards. Nevertheless, the Commission has not been prevented from branching out in new directions, and in her review Dame Lillian Penson stresses the particular value of the creation, as a result of Sir Christopher Warner's proposal, of a Special Citizens' section in the Commission's budget which has enabled the Commission to spend a part of its resources in effecting contact between such groups as social workers and extra-mural tutors. The grant towards the expenses of the teachers in secondary schools exchanging with one another under the scheme for teachers interchange is another development from the original programme, as is the grant made annually for the past three years towards the organization and maintenance of an American Studies Conference at either Oxford or Cambridge in late July or early August to discuss aspects of academic disciplines of interest on both sides of the Atlantic.

Dame Lillian, moreover, lays special stress on the gradual development during recent years of the Colonial programme, in which there is still room for further growth and experiment. The Colonies themselves have welcomed with enthusiasm the seconding to them of the American scholars, and Dame Lillian believes it would be difficult to exaggerate the importance, at this stage of evolution, of the presence of American scholars in these centres of research or teaching. Reviewing this programme in more detail, Sir Raymond Priestley notes that the Commission has now decided to increase to more than 25 per cent the 10–15 per cent of the annual budget expenditure previously devoted to this purpose. Reports made by the American visitors to the Colonies show how significantly these visits are serving the general aims of the Fulbright Programme in promoting international understanding; and although it is too early to assess the contributions to learning which have stemmed from the visits, it is not too early to record the indebtedness of Colonial institutions to the services rendered by their guests. The Royal University of Malta, for example, has profited greatly from the teaching in English literature and in history by a series of Fulbright professors. The administrative problems of the Colonial programme are well on the way to solution in view of the enthusiastic response from the Colonial schools and teacher-training colleges to the initiation in 1952–53 of grants for American school teachers to work in schools and training colleges in the Colonies, and the Commission has decided to use a substantial part of the increase in its Colonial budget for this purpose.

* Fifth Annual Report of the Fulbright Program in the United Kingdom and Colonial Territories, 1949–1954. Pp. 184. (London: United States Educational Commission in the United Kingdom, 1955.)

Describing the Special Categories programme, Mrs. L. M. Cochrane outlines the reasons which led to the selection and visit of a social work survey team whose five members have covered the fields of delinquency (adult and juvenile offenders); family and child care; organization and administration of public services; group work and community organization; and health and rehabilitation. This visit was the outstanding event of 1954: the personal relationships established wherever the members of the team went were extremely successful, and the full written report was to be presented in 1955. The visit has already led to the suggestion that a similar team should survey adult and workers' education and that the Commission should sponsor research teams to visit British Colonial areas; in commenting generally on the British scholars in the United States, Dr. F. A. Young emphasizes that the special categories, broadly speaking, are an investment in adult education, both as a mean of cultural diffusion and as a form of social service which has generated a cluster of rapidly emerging professions including workers' education, social work, library service, museum technology and educational broadcasting. He points out that the visiting scholars in this section move outside the well-worn academic paths and are continuously discovering much that to them is new and exciting. They seem to be nearer to the everyday life of Britain and come closer to the heart of the United States. Accordingly they are in many ways more effective interpreters, promoting understanding where it is most needed, at the base rather than at the apex of our social structure. The large part they have played in the advancement of scholarship and international understanding, writes Dr. Young, is the basic achievement of the British scholar in America; and elsewhere in the report Prof. Una Ellis-Fermor expresses the view that the Commission has given timely help to young and promising scholars visiting Britain who will in all probability be among the leading university teachers of the future.

CENTRAL LABORATORIES FOR SCIENTIFIC AND INDUSTRIAL RESEARCH, HYDERABAD

REPORT FOR 1954

THE annual report for 1954* of the Central Laboratories for Scientific and Industrial Research, Hyderabad, the new buildings of which were formally opened by Pandit Nehru on January 2, 1954, includes the usual lists of papers published during the year and of staff. Two more pilot-plant buildings were due to be constructed in the following year. In the Oils Section, besides investigations on local bleaching earths, samples of triricinolein and sodium ricinoleate were prepared, as well as castor-oil-modified alkyds of 40 per cent, 50 per cent and 60 per cent oil length by the monoglyceride. Work on dehydrated castor oil included its utilization in the preparation of industrial finishes, while studies continued of the antioxidant properties of catechin in fats and oils and of factors affecting the refining of cottonseed oil. In the Entomology Section, work has proceeded on a number of lines: the pharmacological action of the portion of *A. squamosa* seed-oil insoluble in petroleum ether, using the frequency of the isolated heart of the cockroach; the insecticidal properties of chlorinated turpentine against *B. chinensis* and *T. castanium*; the antioxidant properties of catechin against pyrethrum; and the insecticidal properties and spreading pressure of various indigenous oils. The Fibre and Paper Section has been occupied chiefly in putting the pilot-plant project for making hand-made paper on a regular production footing, and the report of the Laboratories is printed on hand-made paper produced by the Section. A comparative study of different types of paper led to improvements in the quality of several types produced by the Section.

The Fuel Section continued its work on the briquetting and the low-temperature carbonization of non-caking Indian coals and on the products of low-temperature carbonization, and its systematic survey of the coalfields of Hyderabad State. In the Heavy Chemicals and Fertilizers Section the utilization of felspar and iron pyrites received further attention, as well as the production of sulphur dioxide from gypsum, while preliminary work was carried out on the preparation of hydrazine hydrate; studies continued in phosphate fertilizers and the preparation of active carbon from vegetable waste materials and from a low-temperature coke. The systematic study of Hyderabad clays continued in the Ceramic Section, and in the Organic Chemistry, Pharmaceuticals and Drugs Section, besides work on Indian turpentine, eucalyptus oil and alkaloids from *Strychnos nux-vomica*, investigations proceeded on the preparation of compounds with œstrogenic activity and of insecticides from phenol and its ether. A number of quinazolines have been condensed with magnesium phenyl bromide to give 3 : 1 : 4-benzoxazines, and some of them were being examined further for hypnotic action. The synthesis of the analgesic, methyl dihydromorphinone (metopon), was being continued on a larger scale.

In the Biochemistry Section the yield of citric acid by fermentation of molasses has been increased by supplements of 0·5–2 per cent of methyl or ethyl alcohol, and further work on the itaconic acid fermentation has confirmed that glycolysis is the initial sequence from sucrose and that the presence of arsenite induces the mould to accumulate keto acid. The oxidation of glucose to gluconic and 2-keto-gluconic acids by *Pseudomonas fluorescens* was studied in greater detail, and an exhaustive examination made of the amino-acids of the protein from the seed-cake *Annona squamosa*. X-ray studies of Indian clays were continued, and in the Physical Chemistry Section the conductivity of sulphuric, nitric and hydrochloric acids in binary mixtures of methyl or ethyl alcohol, acetone, and dioxan with water was determined. Pilot-plant work in the Chemical Engineering Section included the pretreatment of cotton seed, the preparation of dehydrated castor oil and the fractionation of fusil oil on the 'Quickfit' all-glass vacuum distillation unit, while the Section also continued to study the solvent extraction of oil cake and the condensation of saturated vapours. The Operational Research Section examined the possibilities of utilizing pectin in the fruit-preserving industry and the utilization of amosite asbestos fibre for asbestos cement sheets.

* Central Laboratories for Scientific and Industrial Research, Hyderabad. Annual Report, 1954. Pp. xvii+64. (Hyderabad-Deccan: Central Laboratories for Scientific and Industrial Research, 1955.)

COMPRESSED AIR HYGROMETER FOR MEASURING FROST POINT IN THE STRATOSPHERE

THE most satisfactory method of measuring the water vapour content of air in the stratosphere, where the frost point is −75° C. (−103° F.) or less, is to determine the frost point with the Dobson–Brewer frost-point hygrometer carried in an aircraft. In this apparatus the water vapour in the air is condensed as ice on the outside of a thimble cooled internally by cold petrol (cooled by a mixture of petrol and solid carbon dioxide) or by liquid air. The observer adjusts the rate of flow of the cooling liquid and notes the temperatures at which the ice deposit increases and decreases. The mean of these two temperatures is taken as the frost point; there may be an interval of 5–10 deg. C. between them. As the frost point is reduced, the ice deposit becomes thin and more difficult to see and, finally, at frost points below −85° C. (−121° F.) the ice becomes glassy and cannot be seen at all without special optical aid.

Dr. A. W. Brewer (Clarendon Laboratory, Oxford) suggested that the effective range of the instrument could be effectively increased by compressing the incoming air before it reached the hygrometer. Compression raises the frost point, as can be seen from the fact that the humidity mixing-ratio (grams water vapour per kilogram of dry air) is unchanged by the compression. The mixing ratio at the low vapour pressures concerned is proportional to e/p, where e is the vapour pressure and p the air pressure. The ratio e/p is constant in compression so that a ten-fold increase in pressure increases the vapour pressure in the same ratio. This produces an important increase in frost point. Thus, if air with a frost point of −85° C. at the pressure of 115 mb. prevailing at about 50,000 ft. is compressed to 1,014 mb., the mean air pressure at sea-level, its vapour pressure is increased from $23{\cdot}53 \times 10^{-5}$ mb. to $2{\cdot}0757 \times 10^{-3}$ mb. and its frost point correspondingly increased to −71·5° C. (−96·7° F.). A frost point of about −70° C. is much more easily measurable than one of −85° C.

Mr. P. Goldsmith (Meteorological Research Flight of the Meteorological Office) has proposed (*Quart J. Roy. Met. Soc.*, October 1955, p. 607) the use of the engine compressor of a jet aircraft as the source of compressed air. The system has been used on both Ashton and Canberra aircraft, and satisfactory agreement obtained with frost points measured by the normal method. The compressor provides air compressed to a pressure of six to eight times the external air pressure. Goldsmith's article describes in detail the working of the apparatus.

Using this instrument, thirty-five ascents were made from South Farnborough by the Meteorological Research Flight during 1954 to measure frost point in the stratosphere at heights up to 50,000 ft., and the results are given in a paper by R. J. Murgatroyd, P. Goldsmith and W. E. H. Hollings (*Quart. J. Roy. Met. Soc.*, October 1955, p. 533). The compressed air was used above 30,000 ft.; at lower altitudes there is a danger that the high pressure and temperature of the compressed air would damage the hygrometer. They found the frost point decreased steadily with height through the troposphere and that there was usually no change in the rate of fall at the tropopause. In the stratosphere the rate of decrease of frost point decreased with height, and sometimes there was a discontinuity of the rate of fall a few thousand feet above the tropopause. At heights of 10,000 ft. to 15,000 ft. above the tropopause the frost point became almost constant at a value of −82° C. (−115·6° F.) to −85° C. The value was the same in summer and winter. The air here is very dry, having a relative humidity with respect to an ice surface of only 1 per cent. The humidity of the stratosphere is important in the study of the flux of long-wave radiation and of the large-scale circulation of the atmosphere. It is believed that such low humidities are only explicable on the supposition that the air has come from the equatorial stratosphere, being warmed as it does so.

WELDING OF ALUMINIUM AND ITS ALLOYS

THE welding of many commercial aluminium alloys is rendered difficult as a result of their tendency to crack at temperatures above the solidus, or in other cases at much lower temperatures during the cooling of the weld. In 1944 the light-alloy industry initiated a comprehensive series of researches on this problem at the University of Birmingham, the investigations being started under the supervision of the late Prof. D. Hanson and continued under Prof. L. Aitchison. The Aluminium Development Association, in its Research Report No. 27*, has now published a summary of the work of this research team during 1944–50. This quite admirable publication, prepared by Dr. W. I. Pumphrey, a former leader of the team, summarizes the principal investigations and conclusions of the twenty-six papers which have been published.

It was first necessary to develop a hypothesis to explain the high-temperature cracking, and it was shown that on heating to the solidus temperature the ductility fell to zero and the strength dropped rapidly but did not disappear entirely until some higher temperature, still below the liquidus, had been attained. This latter fact was found to be of prime importance, and the temperature above the solidus at which the strength finally disappears emerged as a major factor in the elucidation of the problem.

The development of tests to reveal the susceptibility to both high- and low-temperature forms of cracking was essential to the continuation of this work, and such tests, applicable not only to welds but also to castings, have been developed and are described. The low-temperature form of the defect is connected with the ductility of the material and, in particular, with the nature and mode of occurrence of the brittle intermetallic compounds. Where the weld is under conditions of severe restraint, the presence of these compounds in an intercrystalline form is clearly a source of great weakness.

The other main objective of the work was the development of alloys with good welding and mechanical properties, and three series—the aluminium–copper–silicon alloys, those of aluminium with zinc and magnesium and those with zinc, magnesium and copper—are specifically considered. The tests devised permit the materials to be given at any rate a quasi-quantitative value, and, from this, cracking diagrams have been drawn up for a number of binary and

* Aluminium Development Association. Research Report No. 27: Research into the Welding of Aluminium and its Alloys: a Summary of the Work of the A.D.A. Welding Research Team at the University of Birmingham, 1944 to 1950. Prepared by Dr. W. I. Pumphrey. Pp. 60. (London: Aluminium Development Association, 1955.) 7s. 6d.

ternary alloys together with the quaternary aluminium–copper–magnesium–silicon and aluminium–magnesium–silicon–manganese alloys; in one case, aluminium – zinc – magnesium – copper – manganese, a start has been made on a quinary series.

The work has most clearly justified the time and money expended on it, and this publication provides a first-rate summary of the results which have been obtained.

F. C. THOMPSON

A RARE *CRYPTOMERIA*

YAKU-SHIMA, an island about thirty-seven miles off Kyushu, Japan, and covering approximately 190 square miles, is famed for the forests that cover its steep mountain-sides and for its abundant wild-life, especially deer and monkeys. The really unique and outstanding feature of the island, however, is the *Cryptomeria japonica* or 'Yaku-sugi' trees that are found there. These can be compared with the world's most spectacular trees, both because of their size—they grow to 16½ ft. in diameter and 117 ft. high—and their age, which is calculated to be between 1,000 and 3,000 years old. Their classification in systematic botany is not clear, although they are believed to be the ancestors of the Japanese species of *Cryptomeria*, in spite of differing from them both morphologically and ecologically. At one time there seems to have been a mysterious gap in the species' ecology, due either to its requirements or the conditions it was subjected to, as no trees are to be found between four hundred and eight hundred years old; they are all either older or younger. The Yaku-Shima virgin forests are of great interest, for the Yaku-sugi trees grow there along with firs, hemlock and Yamagurumas (*Trochodendron aralioides*, Sieb. et Zuce), and fill the island's valleys with tall trees decorated with intertwining epiphytic and parasitic plants.

At present, negotiations are going on between the Forestry Agency of the Ministry of Agriculture and Forestry and the National Park Division of the Ministry of Welfare to see whether the area should be designated as a national park. It would be a tragedy if the island's beauty were not perpetuated for future generations, and the International Union for the Protection of Nature has offered all possible help to its member, the National Parks Association of Japan, which in its turn is supporting the National Park Division's project (*Bull. Inter. Union Protect. Nature*, **4**, Nos. 5 and 6; December 1955).

WEATHER AND THE LAND

DURING the early years of his period of office the late Sir Nelson Johnson, director of the meteorological Office during 1938–53, realized that much greater assistance could and should be given by the Office to the economic life of Great Britain. One of his major decisions in this respect was the establishment in 1947 of the Agricultural Meteorological Section of the Climatology Branch, the Section becoming in 1948 the Agricultural Branch of the Office under the assistant director for climatology. Since then the Branch has developed its activities very widely. Besides the Branch office at the headquarters of the Meteorological Office, there are now meteorological advisers at the offices in Bristol and Cambridge of the National Advisory Service for Agriculture, and a meteorologist has recently been posted to the Meteorological Office, Edinburgh, for similar duties in Scotland.

A pamphlet written by the staff of the Branch* explains to the farmer the 'why and how' of his meteorological problems, how meteorologists can help to solve the problems, and how best to use the forecasts prepared at the Central Forecast Office and broadcast by the B.B.C.

The first chapter describes the general climate of the British Isles with special reference to plant growth, and the second gives the local variations in climate associated with altitude, aspect, and the nature of the soil and its covering. The third chapter explains the meteorological aspects of methods available for using solar radiation more efficiently by means of glasshouses and cloches, and methods such as shelterbelts and irrigation, of mitigating unfavourable meteorological effects. After this is a chapter describing the structure of depressions and the use of cloud forms and other portents of weather in interpreting the broadcast forecasts and applying them to local conditions. Finally, the fifth chapter gives the times of and areas used in the broadcast forecasts, lists the local meteorological offices from which forecasts can be obtained by telephone and the various special forecast services such as spell warnings which are available, defines terms used in weather forecasts, and states how the farmer can obtain advice (from headquarters, or from the meteorological offices attached to the National Advisory Service or to the Edinburgh Meteorological Office) on making the best use of his land.

The pamphlet gives a general compendium of meteorological knowledge as applied to agriculture in all its aspects and is of very great value to all agriculturists, while the parts on the use of the broadcast forecasts would be of much value to those whose business or pleasure is affected by the weather. Chapter 4 could well be used in schools for teaching the use of weather forecasts.

* Bulletin No. 165 of the Ministry of Agriculture, Fisheries and Food: Weather and the Land. Pp. iv+35+4 plates. (London: H.M.S.O., 1955.) 3*s.* net.

EMPLOYMENT STATISTICS FOR RECENT BRITISH GRADUATES

A RECENT broadsheet on "Graduates' Jobs", issued by Political and Economic Planning (No. 387), summarizes the results of an inquiry into the careers of 3,961 men who graduated in Great Britain in 1950. Returns were received from some 30 per cent of these, and it is unlikely that there is any main source of bias in the sample; more than half graduated in arts, more than a quarter in science, and less than one-fifth in technology. Many were older than the normal run of graduates, and most had seen war service or had done national service before going to a university. More than half had married by October 1954, and 20 per cent had married in the year they graduated or earlier.

Much the largest entries were into industry and teaching (both 23·4 per cent), mathematics and science teaching claiming 6·7 per cent, while 33 per cent of arts graduates became teachers as compared with 19·9 per cent of science graduates. The Civil Service took 8·6 per cent, 5·5 per cent (or 15·7 per

cent of the science graduates and 3·9 per cent of those in technology) going into the Scientific Civil Service; 7·5 per cent went into commerce, 4·2 per cent into the universities, 4·1 per cent took up law, and 3·6 per cent went into local government service, including 8·3 per cent of the technologists. Of the technologists, 45·4 per cent went into manufacturing industry, 8·8 per cent into building, contracting and civil engineering, 6·5 per cent became consultant engineers and 6·1 per cent entered public utilities.

Industry claimed the highest proportion (23·7 per cent) of first-class honours graduates as well as second-class honours men (20·8 per cent) and 26·4 per cent of others, but over the past four years lost about 10 per cent of its entrants; the Scientific Civil Service claimed 11·0 per cent of first-class honours men and 5·5 per cent of those with second-class honours. Since 1950 it has lost 7 per cent of its intake. The universities, however, which claimed 17·8 per cent of first-class honours men, increased their share of graduates by nearly 4 per cent, whereas school teaching, which by contrast only attracted 2·8 per cent of first-class honours men in mathematics and science, 4·6 per cent of second-class honours men and 10·3 per cent of others (the corresponding figures for arts men being 6·5, 20·6 and 15·2) lost 7 per cent of its original entrants.

Commerce lost 25 per cent of the graduates who started in it; but in general there was a high degree of stability in occupation. Figures for the research associations, which took 2·9 per cent of the science graduates (as compared with 6·0 per cent for the universities) or 1·4 per cent of first-class and 1·7 per cent of second-class honours men, do not suggest that they absorb as yet any considerable proportion of the country's scientific man-power, but rather that their influence may be out of proportion to the numbers, like that of the universities, owing to the high quality.

ENGINEERING RESEARCH IN THE IMPERIAL COLLEGE, LONDON

THE report on research work in the City and Guilds College, 1952–55*, which represents engineering within the Imperial College of Science and Technology, London, where the number of engineering students now exceeds a thousand, appears appropriately when the expansion of the College is being widely discussed in relation to the need for engineers in Britain. Intended for the non-specialist and arranged in six sections, the report gives a readable and illustrated account of the many-sided contribution to national welfare and industrial advance which is already coming from the Departments of Aeronautics, Chemical, Civil, Electrical and Mechanical Engineering and Mathematics. In supersonics, while much effort has gone to the design of the new supersonic wind tunnel for the Roderic Hill Building, some theoretical work has been done on the pressures and forces acting on aircraft fuselages as they move through the air at supersonic speeds; detailed measurements are being made in a 5 ft. × 1 ft. wind tunnel on a jet ejected normal to a stream to determine how and why the jet turns along wind. General methods of analysis of aircraft structures have been developed, including the effects of non-linear elastic behaviour of materials and initial strains which arise with non-uniform heating of a structure. A systematic programme of tests over the past two years on riveted and redux-bonded joints indicates that the glued joints have better fatigue properties than their riveted equivalents, and that alloys of high static strength currently used in aircraft structures may be inferior under repeated loadings, particularly in regions of high-stress concentrations, such as joints, to the lower-strength alloys.

In chemical engineering, in connexion with the design of plant for purifying and liquefying natural gas on a large scale, the physical properties of the gas mixtures present are being further investigated, and an experimental plant has been erected for studying the distillation of liquid air. Problems of mass-transfer in solid–gas, solid–liquid, gas–liquid, and liquid–liquid systems, the drying characteristics of solids, the sedimentation of concentrated suspensions of particles in a liquid, fluidization of particles by means of an upward current of liquid, and transport by means of a gas or liquid are also being investigated, and an apparatus has been set up for studying both the sublimation of pure solids and the technical process of freeze-drying. The growth of an organic crystal from the melt has been investigated by a method in which the growth of individual faces is measured directly with a travelling microscope. The compressibilities of mixtures of steam and carbon dioxide have been measured up to 100 atmospheres and 650° C. In the high-speed fluid kinetics laboratory, the high-pressure supersonic flow through nozzles and the design of such nozzles for hot and cold gases are being studied, as well as the formation and disintegration of jets and sheets and the design of nozzles for atomization. Methods for concentrating low-grade iron ores have been examined, and an experimental technique has been designed for subjecting typical blast-furnace charges to the conditions they would encounter in descending the furnace. Other researches have been concerned with the basic chemical physics of gases and vapours, the melting of crystals containing organic molecules, mechanical wear and lubrication, the abrasion of copper and iron surfaces, flame spectroscopy and the accurate and detailed analysis of the peroxides, aldehydes, ketones, olefins and other intermediate products in the oxidation of hydrocarbons; and a fruitful study has been made of engine crank-case explosions.

In civil engineering, in connexion with the design of a large arch dam to be constructed at Dokan, Iraq, on a tributary of the Tigris, the elastic equations governing the stress distribution have for the first time been solved numerically, and the work assisted and confirmed by experimental methods using a material which has only recently become available. Work on thin-walled rectangular box girders conducted for the British Shipbuilding Research Association confirmed that introduction of expansion joints is a practice to be avoided. The Department has also fostered the application of simplified models to the analysis of building frames. Much work has been done on the fundamental strength and deformation characteristics of both reinforced and pre-stressed concrete framework members. Experiments on curved channels have yielded far-reaching results, and definite progress has been made in studying the movement of sediment along a river bed. Of particular interest are the work on the action of wind

* Imperial College of Science and Technology (University of London). Report on research work in the City and Guilds College, 1952–55. Pp. ii+61. (London: Imperial College of Science and Technology, 1955.)

on a water surface, bearing directly on the North Sea floods of 1953, and the construction in the laboratory of a model of the Lynmouth valley with which a relation was established between the quantities of water flowing through the model and the corresponding water-levels. The resulting estimate of the flood was used by the engineer advising on the reconstruction of the damaged parts of Lynmouth. Further investigation of spillways, the fundamental and practical aspects of the shear strength of soils, the stability of earth dams and of clay slopes in railway, road and canal cuttings, the settlement of buildings, the sedimentation of water or sewage, the filtration of water through sand, and a continuing physical, chemical and biological study of new impounding reservoirs are other subjects in which the investigations of the Department directly impinge on public health or safety.

In the Department of Electrical Engineering, studies have been made of the effect of eddy currents in unlaminated materials in electrical machines, of cross-magnetization on the characteristics of a cross-field generator and of saturation and armature reaction on the building-up curve of a d.c. exciter supplying the field-winding of an alternator. Studies in the Power Systems and Computer Laboratories of physical phenomena arising in the transmission and utilization of electrical energy have involved the development of special measuring equipment. Other work has concerned the improvement of methods available for carrying out the numerical calculations required in engineering design and research. Special efforts have been made to develop and extend the statistical methods of control design. The Department has also engaged in research on human perception, especially speech and hearing, as well as various circuit applications of transistors, the distortion of microwaves resulting from the presence of dielectric and conducting cylinders and the determination of the reflexion coefficient of a set of parallel plates similar in form to those used in constructing lens aerials. Work in the Ultrasonics Laboratory is concerned with the behaviour of solids, liquids and gases under the influence of ultrasonic waves of varying frequency. The application of the so-called corona effect of high voltage in dry air has also been studied.

Researches in heat transfer in the Department of Mechanical Engineering have been concerned with the utilization of low-grade heat, with marine condenser tubes, with thermal stresses in steam turbine rotors, and heat transfer to gas turbine blades, as well as with heat transfer from a rotating disk. Other investigations have been concerned with combustion in reciprocating engines, the vibration of propagating flames, combustion in gas turbines and the use of the gas turbine for chemical reactions such as the cracking of methane to acetylene. A theoretical study has been completed of the stresses in and flexibilities of curved pipes, and the axial compression of six expansion bellows of three different types has been examined experimentally by electrical resistance strain-gauge surveys. Some plane strain processes are being examined to determine the region over which plane strain conditions apply, and to establish means for obtaining basic stress–strain curves for metals at deformations much greater than those attainable in the standard tensile test. A programme of research in photoelasticity is concerned with the possible extension of the method to the examination of materials which have been plastically deformed, and under another programme the failure of materials under relatively few cycles of high stress-intensity is being examined with the view of obtaining fundamental knowledge on fatigue as well as design data. Besides the study of the troublesome vibration known as 'oil-whirl' and thin-film lubrication, a vibrational method is being developed for the fatigue testing of metals, and an apparatus has been built for vibrating cantilevers of various shapes in several modes of bending and torsion.

In the Department of Mathematics, a major investigation was concerned with the design of an arch dam, and others with the numerical solution for the flow of a viscous fluid past fixed obstacles, and the temperature distribution in two conductors sliding over one another and generating heat by friction over their area of contact.

SPIRAL PATTERNING OF SOLAR CORPUSCULAR PRECIPITATION

By E. R. HOPE

Defence Research Board of Canada, Ottawa

THE plots of radio blackout distribution in the North American and North Atlantic region, as published by V. Agy[1] and J. H. Meek[2], agree with the isochrons of the 'morning' maximum of magnetic disturbance in the Arctic region, as found by (anonymous) Soviet research[3,4]. Fig. 1 (from ref. 3) shows these isochrons (geographical loci of simultaneous occurrence), which may be explained by a diurnally rotating spiral of solar corpuscular precipitation. Fig. 2 reproduces Agy's Figs. 5 and 6 [1].

To interpret Agy's and Meek's local-time plots, which show peculiar southward lobes centred at about long. 90° W. (as in the right-hand side of Fig. 2), W. R. Piggott[5] tried plotting in G.M.T. the longitudes where the maximum rate of occurrence of blackout (storm-*D* ionization) is found. This plot, extending over the Atlantic-Canada sector only, showed an apparent east-to-west rotation-period of 48 hr., on which basis Piggott suggested that there must be two *D*-region activity centres, separated by 180° of longitude, and rotating around the pole once in two days. Agy[1] then tried changing his local-time plot (Fig. 2, right) to a G.M.T. plot. This eliminated the lobes and clearly displayed the apparent 180° rotation in 24 hr. (Fig. 2, left).

Table 1 shows the G.M.T. isochrons in Fig. 1 and Fig. 2 (left), with the longitudes where they cross the circle of latitude 60° N.

Allowing for the fact that Agy's plot is for the summer season only, while the Russian data are probably for the whole year, the agreement of isochrons 00–14 is excellent. The directions of these isochrons also correspond rather well, as may be judged by visual comparison.

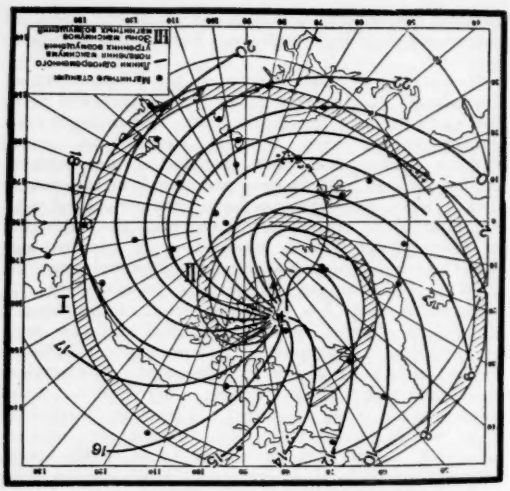

Fig. 1. Isochrons of morning maximum of magnetic disturbance (the figures attached to the isochrons represent world time). ●, Magnetic stations; —, isochrons of maximum of morning disturbance; I and II, maximum zones of magnetic disturbance. The figure, which is taken from ref. 3, is inverted to facilitate comparison with Fig. 2

We conclude that Agy's G.M.T. isochrons 00–14 are low-latitude continuations of the Soviet isochrons. (The disturbance-spiral, on magnetically disturbed days only, may extend its effects far southward; its passage appears to be detectable in the earth-currents at Tucson. See translator's comments to ref. 6.)

One is impressed by the complete independence of the work and data in the two cases. Soviet isochrons: diurnal maximum of magnetic disturbance (probably based on amplitude of magnetic variation); Agy's isochrons: maximum of fundamental Fourier harmonic of diurnal variation of *F*-layer blackout probability (*D*-layer or *E*-layer absorption).

A fact of capital interest is that west of isochron 14 the agreement abruptly disappears. Yet the northern parts of the isochrons (14, 16, 18) still agree, in both position and direction. Above 70° N., this is true even of isochrons 20, 22, 00. On Fig. 2 (left), a smoothly curving line may be drawn, beyond which the Soviet isochrons seem to disappear suddenly under a different set of north–south contours (cf. ref. 4, pp. 19, 23, "axis maximum" and its times). It will be interesting to pencil in, on the charts, the position of the great Arctic magnetic anomaly[2], and to compare it with the sharp bends in Agy's isochrons.

Now the non-uniform rotation (Fig. 1) of the disturbance-spiral accounts precisely for Piggott's apparent 48-hr. period. Between isochrons 00 and 12 in the Atlantic sector, it will be seen that the spiral is rotating just half as fast as the sun.

Farther west, the accelerated rotation (Fig. 1) must enfeeble the disturbance effect by spreading it over a larger area. This would help the disappearance of the Soviet isochrons under what we suppose to be the independent contours in the Bering Sea area (ref. 4, p. 21).

Whereas the G.M.T. plot shows actual momentary positions of the disturbance wave, the local-time plot only shows synchronic relationships along each meridian separately. In Fig. 2 (right), the northward progression of the local-time isochrons is due to the rotation of the disturbance-spiral, for along any given meridian the motion of the spiral is poleward. The 'lobe' shape, a kind of artefact, is produced as follows. In the eastern half of the lobe the sun is gaining on the spiral; if the observer moves from meridian to meridian at the sun's speed (as in this plot), he sees the spiral in this region turning backward, west to east, and its arm moving south. The bottom of the lobe marks the point where the speeds of the sun and the spiral are about equal. After this, the spiral gains on the sun, and appears to move north along the meridian.

What the local-time plot provides is a graphical comparison of velocities. From the uniform orientation (toward 90° W.) of the contours in the lobe, and their uniform spacing, we see that different segments

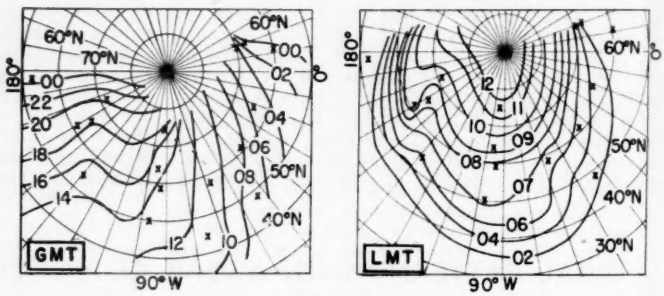

Fig. 2. Time of maximum percentage of time of blackout φ_1 during summer (from Vaughan Agy, ref. 1)

of the disturbance wave are rotating at different velocities (that is, the spiral is progressively deformed) and that the rotation-velocity of each segment depends only, or mainly, on longitude.

Table 1

Isochron	Crosses 60° N. at longitude: (Agy, Fig. 2)	(U.S.S.R., Fig. 1)
G.M.T. 00	15 E.	10 E.
02	0	5 W.
04	20 W.	15
06	35	27
08	45	41
10	60	57
12	75	69
14	95	83
15	—	100
16	115	115
17	—	170 (extrapolated)
18	—	120 E. (extrapolated)
20	160 W.	60 E.
22	167 W.	25 E.
00	175 W.	10 E.

I am grateful to Dr. Vaughan Agy for permission to reproduce Fig. 2, and to the Canadian Defence Research Board for authorizing publication of this communication. [Oct. 22

[1] Agy, V., *J. Geophys. Research*, **59**, 4, 499 (1954).
[2] Meek, J. H., *J. Geophys. Research*, **57**, 2, 177 (1952).
[3] New Soviet Researches, Explorations and Discoveries in the Central Arctic. *Izv. Akad. Nauk*, Ser. Geog., No. 5, 3 (1954). English translation in Canadian Defence Research Board Pub. *T* 165 *R* (Ottawa, 1954).
[4] Hope, E. R., Canadian Defence Research Board Pub., *T* 165 *R* (Ottawa, 1954).
[5] Piggott, W. R., *Nature*, **171**, 124 (1953). See also Agy, V., *Nature*, **173**, 445 (1954).
[6] Yanagihara, K., Disturbance Daily Variation of Earth Currents at Kakioka. Memoirs Kakioka Magnetic Observatory, **7**, 1, 49 (1954). Translation in Canadian Defence Research Board Pub. *T*53 *J* (Ottawa, 1955).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Immunological Methods in Plant Taxonomy

THE application of immunological analysis to plant taxonomy has been made practicable by the development of gel-diffusion methods, both by the Elek–Ouchterlony technique[1] and by the more recent immuno-electrophoretic technique of Grabar and Williams[2]. By these means the individual proteins in plant extracts may be differentiated and the extracts compared component by component with those from related species. We have applied a modification of these general methods to the investigation of the genus *Solanum*, with particular reference to the interrelationships of certain Mexican species of potato, and the comparison of these with *S. tuberosum*, the domestic potato.

Thin slices of tuber of each species were soaked in sodium hydrosulphite (0·7 per cent solution) for 30 min., rinsed in distilled water and the sap expressed by crushing the slices, supported within folded strips of moist calico, through stainless steel rollers. Antisera were raised in rabbits to crude saps from *S. tuberosum* and *S. ehrenbergii* (a Mexican species), using a combination of Freund's adjuvant technique[3] with courses of intravenous injections. Agar containing veronal buffer (*p*H 8·5) was poured to a depth of 2 mm. on lantern slides in 'Perspex' frames; in the agar, holes were cut with a cork-borer to hold the tuber extracts to be compared, and a trough at a distance of 1 cm. to hold the antiserum. The reagents were allowed to diffuse towards one another and lines of precipitate formed, each line corresponding to an antigen–antibody system. Where lines from different extracts joined end to end they were assumed to belong to identical or cross-reacting proteins. In some cases a much improved separation of the lines was obtained by subjecting the antigen to a short (4-hr.) electrophoresis before adding the antiserum (Fig. 1).

(i) (ii)

Fig. 1. *S. tuberosum* reacting with homologous antiserum. (i) Without electrophoresis the antigen shows only two lines of precipitate; (ii) with electrophoresis, one of the lines has been split into three, and their relative positions changed

With both antisera, well-marked cross-reactions occurred between all the forty species examined; but by comparison of the 'line spectra' and by cross-absorptions of the antisera, it was possible to divide the species into well-defined groups.

By using *S. tuberosum* antiserum, the fourteen Mexican species were separated into three divisions (Fig. 2*a*) and then by the use of the antiserum against *S. ehrenbergii* two of these could be further subdivided, giving a total of five groups (Fig. 2*b*). Each group, with the exception of one, corresponded to a particular taxonomic series according to the classification proposed by Hawkes[4]; the one exception (Group 4) contained species from two series. The taxonomic series corresponding to the groups mentioned here are as follows: Group 1. Series *Morelliformia*. Group 2: Series *Pinnatisecta*. Group 3: Series *Cardiophylla*. Group 4: Series *Demissa*, and *Longipedicellata*; *S. tuberosum* and other South American species. Group 5: Series *Bulbocastana*.

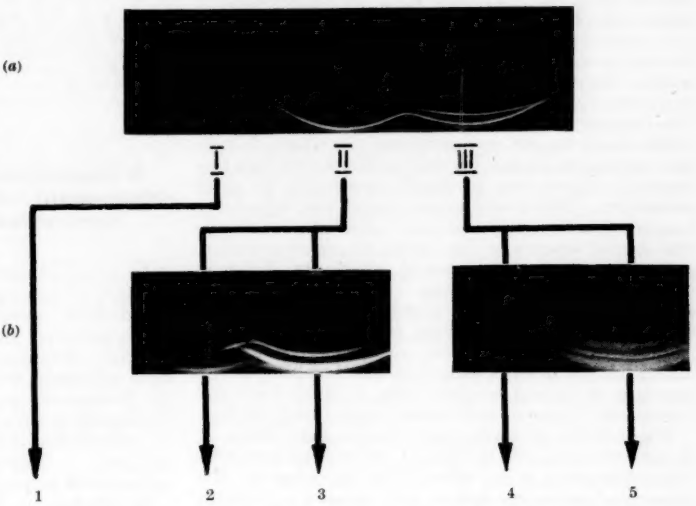

Fig. 2. (*a*) Separation of the species into three divisions with *S. tuberosum* antiserum. (*b*) The splitting of group II into two by means of unabsorbed *S. ehrenbergii* antiserum and of group III into two by means of the same antiserum absorbed with *S. tuberosum* extract

These results will be published in detail elsewhere. The work is being carried out mainly under a grant from the Nuffield Foundation.

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Effects of Single and Fractionated Doses of X-Rays on Mouse Embryos

That embryonic tissues *in vitro* may be affected more drastically by fractionated, than by single, doses of X-rays was shown by Spear in 1932 [1]. Working with chick embryo fibroblasts, he demonstrated that the depression of activity of these cells is far greater with two 2½-min. exposures separated by 80 min. than with a single 5-min. exposure. In view of the possible significance of these findings for our understanding of the nature of embryonic damage resulting from X-irradiation, and in view of the general interest in the question of radiation hazards to the developing mammalian embryo, the present experiment was designed to determine whether there is a difference between the effects of single and fractionated doses of X-rays on developing mouse embryos *in vivo*.

Strain-101 female mice were mated to strain-*C3H* males and irradiated with X-rays (250 kVp., 15 m.amp., 3 mm. aluminium, half-value level 0·4 mm. copper, 80 r./min.) 9½ days after the appearance of copulation plugs. Irradiation was administered either as a single dose of 300 r. or as three 100 r. fractions at 30-min. intervals. Embryos were obtained by dissection three to six days after irradiation. The majority of dissections were made on coded animals. The criteria used were lumbo-sacral spina bifida and coloboma of the eye, two abnormalities which, following irradiation on day 9½, are produced with high frequency [2] and are easy to classify accurately by gross inspection. The lumbo-sacral region was scored for length of antero-posterior axis affected; each eye was scored separately for extent of pigment defect.

The two criteria represent strikingly different developmental disturbances. The lumbo-sacral damage consists of a disorientation of the neural tube and somites, resulting in neural arch malformation; the eye defect represents an altered differentiation of optic cup elements, resulting in the presence of retinal sensory cells in areas normally consisting of pigment epithelium (unpublished results).

The results of single and fractionated doses of X-rays are compared in Table 1. While the incidence of malformation is not affected by fractionation, the severity of embryonic defects is far greater in response to a fractionated dose than in response to a single dose. A striking parallel can be seen between the relative effects of these two methods of irradiation on the lumbo-sacral axis and on eye pigmentation.

It would be premature to speculate on the nature of the processes responsible for the differential effect of single and fractionated irradiation on development.

Table 1. Comparison of the Effects of Single and Fractionated Doses of X-Rays on Developing Mouse Embryos

	Lumbo-sacral region				Eye pigment formation			
	300 r. single dose		300 r. fractionated dose		300 r. single dose		300 r. fractionated dose	
		(per cent)		(per cent)		(per cent)		(per cent)
Normal	12	11·4	12	15·0	33	15·7	22	13·8
Mildly abnormal*	90	85·7	17	21·3	158	75·2	29	18·1
Severely abnormal†	3	2·9	51	63·8	19	9·0	109	68·1
Total	105		80		210		160	

* Includes all embryos in which the extent of abnormality (measured in mm. of lumbo-sacral axis and percentage of eye surface) is less than half that found in the most abnormal embryo.
† Includes all embryos in which the extent of abnormality is at least half that found in the most abnormal embryo.

However, from the point of view of developmental mechanics [3], any interpretation of the nature of embryonic damage in response to X-irradiation must consider the present results, namely, that in the two widely differing embryonic systems so far studied, fractionation is more effective than a single dose, and the degree of increase in effectiveness is similar in the two systems. From the point of view of radiological practice [4], the demonstration that short-interval fractionation can increase the radiation hazard to developing embryos *in vivo* adds yet another factor calling for caution.

This work was carried out under contract *W*-7405-*eng*-26 for the Atomic Energy Commission.

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A Requirement for Catalase in Tyrosine Metabolism: the Oxidation of *p*-Hydroxyphenylpyruvic Acid to Homogentisic Acid

In this communication evidence is presented that catalase is required in one of the steps of tyrosine metabolism, namely, the conversion of *p*-hydroxyphenylpyruvic acid to homogentisic acid. This oxidation requires two protein fractions which have been separated and partially purified from dog liver by treatment with organic solvents followed by fractionation with ammonium sulphate [1]. Fraction *A* is precipitated by 0·40–0·55 saturated ammonium sulphate; fraction *B* by 0·60–0·75 saturated ammonium sulphate.

In studies to establish the function of the two protein components, it was observed that fraction *A* contained appreciable amounts of catalase and that the activity of this fraction was proportional to its catalase content. Further experiments showed that fraction *A* could be replaced by purified catalase obtained from beef or rat liver (Table 1). The product formed from *p*-hydroxyphenylpyruvic acid with fractions *A* plus *B* or with catalase plus fraction *B* was identified as homogentisic acid by chemical analysis and by paper chromatography with methods previously described [2]. Catalase appears to be specifically required in this oxidation, and could not be replaced by ferritin, hæmoglobin or cytochrome *c*.

Various amounts of catalase were added to constant amounts of fraction *B* (sufficient in the presence of excess catalase to oxidize 5 μmoles of substrate in one hour) to study the effect of catalase on the reaction. When catalase was present in limiting amounts, the rate of reaction, as measured by oxygen uptake, was proportional to the amount of catalase added. 5γ of catalase was sufficient to give about one-half the maximal rate and 1γ produced significant activity. However, at least 30γ of catalase was required to give the maximal reaction-rate. The low activity observed when fraction *B* was tested alone

Table 1. Effect of Various Catalase Preparations on the Oxidation of *p*-Hydroxyphenylpyruvic Acid to Homogentisic Acid

Incubation conditions: The main compartment of the Warburg vessels contained 1·0 ml. of 0·2 *M* phosphate buffer, *p*H 6·5, 20 μmoles of neutralized glutathione, 100γ of 2,6-dichlorophenolindophenol, the enzyme preparations described below and water to make a total volume of 2·0 ml. The side-arm held 5 μmoles of *p*-hydroxyphenylpyruvic acid in 0·5 ml. of 0·2 *M* phosphate buffer, *p*H 6·5, or buffer alone in the control flasks. The centre well contained 0·2 ml. of 20 per cent potassium hydroxide. Incubation was at 37° C. for 1 hr. with air as the gas phase and a shaking rate of 180 oscillations per min.

Catalase preparation Source	(Per cent purity)	γ of catalase*	Fraction *B* (900γ/flask)	Substrate oxidized in 1 hr. (μmoles)
Rat liver†	86	28·8	−	0
Beef liver‡	20	432·0	−	0
Beef liver	20	27·0	+	4·8
Rat liver	86	28·8	+	4·9
Rat liver	86	9·6	+	3·9
Rat liver	86	4·8	+	2·5
Rat liver	62	5·0	+	2·5
None	—	—	+	0·7

* Based upon the activity of pure rat-liver catalase; 1 unit of activity is defined as the amount necessary to decompose 63·2 per cent of the remaining peroxide in one sec. 1 unit of activity is equivalent to 5·85γ of pure rat liver catalase. We are indebted to Drs. R. Greenfield and V. Price for assay of these preparations.

† The rat liver catalase preparations were kindly supplied by Dr. R. Greenfield. The principal contaminant in these preparations, a protein with S_{20}, *W* of 6·3–6·5 (ref. 8), was eliminated as the active component by comparing the activity of catalase preparations of different purity.

‡ Crystalline beef liver catalase from Worthington Biochemical Corporation.

(Table 1) was probably due to a small amount of catalase still present, since it is very difficult to obtain fraction *B* completely free of catalase.

When large amounts of catalase (432γ) were incubated with all additions except fraction *B*, no oxidation of *p*-hydroxyphenylpyruvic acid occurred (Table 1). Even in the presence of enzymatically generated peroxide, catalase did not catalyse the oxidation of *p*-hydroxyphenylpyruvic acid to homogentisic acid.

The exact mechanism by which catalase participates in this reaction has not been established. If hydrogen peroxide is involved, it would have to arise from the oxidation of *p*-hydroxyphenylpyruvic acid, since there is no oxygen uptake in the absence of the substrate.

It is well known that catalase can function as a peroxidase with various compounds[3], such as alcohols[4,5], nitrite[6], phenols and amines[7], and it has long been suspected that under physiological conditions catalase may not only decompose hydrogen peroxide but also participate in oxidative reactions. The present studies on the oxidation of *p*-hydroxyphenylpyruvic acid to homogentisic acid have demonstrated, for the first time, a requirement for catalase in the oxidation of a normally occurring substrate. It is possible that catalase, in association with other oxidases, may participate in other reactions of this type.

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Effect of Blocking the Reticulo-endothelial System on the Storage of Vitamin A Ester and Alcohol in the Liver of the Rat

Vitamin A is absorbed through the lymphatic system mostly in the esterified form[1] and is stored in the liver predominantly as ester with small amounts of the free form. Its absorption via the lymphatic route raises the question of the reticulo-endothelial system being associated with its storage mechanism in the liver. Experiments, carried out in this laboratory, consisting of intraperitoneal injection of indian ink followed by oral administration of oily solutions of vitamin A, show a marked interference in the deposition of the esterified form of the vitamin in rat liver, the free form remaining unaffected.

Male rats of this Institute were raised on a diet low in vitamin A composed of white rice, casein, yeast, groundnut oil and minerals, and were used when they weighed 75–100 gm. One group of rats was kept on the basal diet alone to serve as negative control; each of a second group of six rats was given one intraperitoneal injection of 1 ml. of normal saline daily for seven days and a single oral dose of 3,000 μgm. of vitamin A in 0·2 ml. of groundnut oil on the last day of the injections, and a third group of six rats received treatment similar to the second group, except that 1 ml. of a 20 per cent suspension of indian ink ('Reeves Fixed Indian Ink') in normal saline, instead of normal saline alone, was used. All rats were fasted for 24 hr. after the dose and bled to death by drawing as much blood as possible from the heart while under light ether anæsthesia. Plasma was extracted according to the method of Kimble[2] and the liver with anhydrous sodium sulphate and peroxide-free diethyl ether[3]. The two forms of vitamin A were separated and determined as described by Ganguly *et al.*[4], excepting that a Klett-Summerson photoelectric colorimeter, with a red filter, standardized against standard vitamin A, was used for the determination of the Carr–Price reaction.

The results, as presented in Table 1, show a markedly lower concentration of the ester form of vitamin A in the liver and a markedly higher value of the same form in the blood of rats treated with indian ink, as compared to those treated with saline, demonstrating that blocking of Kupffer cells interferes with the storage of vitamin A ester in the liver of the rat; this confirms the earlier findings of Kagan *et al.*[5] in the guinea pig. In contradistinction to the vitamin A ester values, the vitamin A alcohol values are almost unaffected in the liver, probably indicating different mechanisms of storage of the two forms of vitamin A in the liver and lending

Table 1. Effect of Intraperitoneal Injection of Indian Ink on the Vitamin A Ester and Alcohol Values in Blood and Liver of Rats

No. of rats	Treatment	Blood (μgm./ml. plasma)		Liver (μgm./organ)	
		Vitamin A ester	Vitamin A alcohol	Vitamin A ester	Vitamin A alcohol
6	Negative control	*	*	10·2 (8–12)	1·4 (1–1·8)
6	Saline + 3,000 μgm. vitamin A	1·9 (1·6–2·2)	1·2 (0·8–2·0)	2,238·3 (1,980–2,450)	56·0 (45–65)
6	Indian ink + 3,000 μgm. vitamin A	5·1 (3·5–8)	1·9 (1–2·5)	1,168·8 (900–1,322)	54·3 (47–61)

* Too low for determination.

support to such a concept put forward by Krinsky and Ganguly[6]. In separate preliminary experiments, in which liver homogenates of normal stock rats were dialysed against a series of buffers ranging from *p*H 7·0 to *p*H 4·0, we have found that the two forms of vitamin A are precipitated at different *p*H values. This observation also lends further support to this concept. Further work is in progress and a detailed report will be published elsewhere.

This investigation was aided by a research grant from the Indian Council of Medical Research and by the Rockefeller Foundation.

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Differences between the Electrical Charge carried by Normal and Homologous Tumour Cells

Differences between the behaviour of normal fibroblasts and sarcoma cells have been observed in tissue culture by Abercrombie and Heaysman[1]. Normal fibroblasts affect each other's movements by contact inhibition, whereas sarcoma cells do not show inhibition either with respect to each other or to normal fibroblasts. Time-lapse colour films taken with the interference microscope (shown at the Bristol meeting (1955) of the British Association by E. J. Ambrose and M. Abercrombie) have shown that this difference in behaviour is due to differences in the mechanism of contact formation in the two cases, being dependent upon a loss of adhesiveness of the cell surface of the tumour cells. This reduction in the adhesiveness of the tumour cell suggests that the electrical properties of the surface may have altered during the malignant transformation. These properties may be investigated by electrophoretic measurements of cellular mobility. For example, studies of bacteria during growth, in the presence of bacteriostatic agents, have revealed marked changes in the nature of the cell surface, changes which are passed on to the progeny during subsequent growth, either in the presence or the absence of the drug. Thus the growth of *Aerobacter aerogenes* in the presence of proflavine[2] or crystal violet[3] gives rise to new populations of cells, which, although biologically indistinguishable from the original strain, have a distinctive electrometric behaviour.

The electrophoretic technique used for this work[4] has now been extended to a study of the surface behaviour of normal and homologous tumour cells. The tissue cells, separated by the perfusion method of Anderson[5], were washed twice on a centrifuge run at low speed with *M*/30 phosphate buffer solution (*p*H 6·8, ionic strength 0·13) and finally suspended in the same solution. Tumour cells and red blood

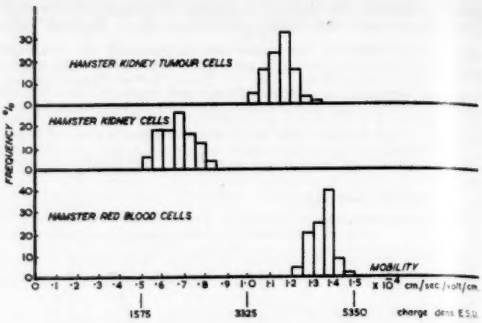

Fig. 1. Electrophoretic mobilities of intact cells. Histograms showing the mobility of red blood cells, normal and tumour kidney cells of the hamster. Each cell type shows a Gaussian distribution about the mean

cells were washed in a similar way. All determinations of mobility were carried out in the buffer solution. Samples of hamster kidney tumours[6] induced by stilbœstrol were obtained in a highly distinct and compact form. Samples of rat liver tumours induced by butter yellow were also examined. Red blood cells from the same tissues were used as internal controls. This method eliminated any possibility of alterations due to changes in the serum proteins of the tissues, which could become absorbed on the cell surface. Red blood cells for a given mammal were found, in fact, to have a mobility which was independent of their source. Preliminary studies of ascites tumour cells (mouse Ehrlich carcinoma) showed that the mobility of the intact cells was independent of size of cell and tumour age.

Typical histograms for the normal and homologous tumour kidney cells are shown in Fig. 1. The average charge density of the tumour cells is almost twice that observed with the normal cells from which they have been derived. A similar increase in mobility was observed with the liver tumours. In this case, the tumour values were not so homogeneous, because these tumours are more diffuse than kidney tumours and suffer from some contamination with normal cells. The increase in the mobility of the tumour cells indicates either a change in the number of charged groups attached to the high-molecular weight material, for example, the carboxyl-rich chains of the protein, or a change in the ability to absorb positive ions. That the latter may in fact be the case is suggested by observations of de Long, Coman and Zeidman[7], that tumour tissues show a decreased calcium content in comparison with normal tissues.

Changes in the nature of the cell surface may possibly provide a new approach to the chemotherapy of cancer and enable a preferential attack to be made on the malignant cell.

We thank Prof. A. Haddow for his interest in this work, and we are indebted to Prof. J. A. V. Butler for valuable help and suggestions. We also wish to thank Dr. E. Horning, who supplied the samples of hamster kidney tumours, and Dr. D. Darcy, who supplied the rat liver tumours. One of us (J. H. B. L.) acknowledges continued financial support from the British Empire Cancer Campaign. This investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the

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Influence of a Magnetic Field upon the Leucocytes of the Mouse

THIS communication contains the results of one part of the research programme aimed at studying the effect of magnetic fields on living organisms and tissues. Female *C3H* strain mice from the Roscoe B. Jackson Memorial Laboratory were kept for 4–5 weeks in magnetic fields of 4,200 gauss strength, produced by 'Alnico' permanent magnets. The animals were placed in individual cages 3·5 in. inner diameter and 1·40 in. height. The magnetic field-strength was in the centre of the cages 4,400 gauss, decreasing to 4,000 gauss toward the periphery of the cage, as measured with a Dyne-Empire Model *D*-79 gauss meter. Control animals were kept in identical cages, wherein the pole-pieces of the magnets were simulated with 1-in. thick brass disks to provide identical conditions with respect to temperature, illumination and cosmic radiation[1]. The food of the animals consisted of standard Rockland mouse diet in pellet form. Blood samples taken from the tail at intervals of 7–14 days were investigated with respect to white blood count, red blood count and differential count.

The first experimental series was performed on mice forty weeks old during the spring of 1955. In this series nine mice were kept in magnetic fields for five weeks and in standard plastic cages, 4–5 animals in each cage, for an additional eight weeks after removal from the field. In this series no control animals were used.

The second similar experimental series was performed during late summer and autumn of 1955 on mice nine weeks old. In this series, nine mice were kept for four weeks in the magnetic fields and remained during the fifth week in their individual cages, however, removed from the field. Thereafter they were transferred to standard plastic cages, 3–4 animals in each cage for an additional thirteen weeks. In this series four control mice were kept for five weeks in individual cages and thereafter transferred to a plastic standard cage. The blood samples were taken from all animals, treated and controls alike, always on the same dates.

(*a*) In both series a significant decrease in the number of segmented cells is observable within the first two weeks while the animals were kept in the magnetic fields. This change cannot be attributed to the confinement to small cages, because the controls confined to identical cages seemed rather to indicate an increase in the number of segmented cells. The average decrease is $28{\cdot}7 \pm 6{\cdot}7$ per cent for the first and $47{\cdot}9 \pm 8{\cdot}6$ per cent for the second series (errors mean standard errors); indicating that the effect is significant on the level: $P < 0{\cdot}001$. Table 1 illustrates for the animals of the second series the individual differences between starting value (base line) and lowest value reached within the first fourteen days, as a percentage of the starting value.

(*b*) After removal from the magnetic field the number of segmented leucocytes increases and reaches a maximum a few weeks after removal from the field. The mean increase is for the first series 135 ± 30 per cent and 226 ± 65 per cent for the second, expressed in per cent of the minimum. These values indicate that the effect is significant on the probability level: $P < 0{\cdot}001$. That this maximum cannot be considered as a result of the transfer of the animals from the small cages to standard cages is proved by two circumstances: (1) no such increase was observed with the controls; (2) the majority of the mice manifested the maximum in the number of segmented cells one week after removal from the field; that is, at a time when they were still in small individual cages.

(*c*) The increase is followed by a decrease below the base-line value; the mean decrease being $59{\cdot}4 \pm 7{\cdot}0$ per cent in the first and $33{\cdot}2 \pm 8{\cdot}2$ per cent in the second series; the values given in per cent of the previous maximum. This effect is significant on the probability level: $P < 0{\cdot}001$.

(*d*) In the second series, where the observations were continued over a period of 124 days, the last counts again gave base-line values.

In the number of the lymphocytes a significant increase was observed in both experimental series after the animals were removed from the magnetic fields. The mean increases between the value shown at the time of removal and the following maximum, expressed as a percentage of the lower value, were: 270 ± 56 per cent in the first and $28{\cdot}1 \pm 6{\cdot}5$ per cent in the second series respectively. The effect can thus be considered significant on the probability level: $P < 0{\cdot}001$. The control animals did not show any significant change in the number of their lymphocytes. The count taken on the 124th day in the second series seems to indicate an increase of $38{\cdot}6 \pm 16{\cdot}6$ per cent above the base-line value; however, the probability-level of this effect is only $P = 0{\cdot}02$. No significant change was observed in the red blood count in either of the two experiments.

The observations on histological changes of organs of the mice kept in a magnetic field will be published elsewhere.

Table 1

No.	2	3	4	5	6	7	8	9	0	Mean
Treated	−60·3	−58·5	−23·6	−10·2	−68·7	−30·7	−69·0	−26·0	−84·5	−47·9±8·6
Controls	+72·8	+193	−38·2	+14·4						+61 ±50

We wish to acknowledge the valuable technical assistance of Miss Martha Walker, who did the hæmatological work. We also wish to express our gratitude to the Dorothy Shattuck-Stensland Foundation for the generous grant which enabled the purchase of the magnets and covered all experimental expenses. Acknowledgment is due to the Administration of St. Francis Hospital and particularly to Dr. J. W. Henry, head of the Pathology Department, for his valuable advice, as well as to the Forro Scientific Co. for permission to conduct some experiments in their laboratories.

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Effect of Cortisone on the Serum Gamma-Globulin

Nicol and Snell[1] showed that cortisone depresses the phagocytic activity of the reticulo-endothelial system during the first two weeks of treatment, and that if the cortisone injections are continued the reticulo-endothelial system apparently recovers during the third and fourth weeks. Nicol and Bilbey[2] reported that cortisone also produces changes in the blood. They showed that when 10 mgm. of cortisone is given daily intramuscularly for one or two weeks, the total leucocyte count falls, due to reduction in the number of lymphocytes and polymorphs; but if the cortisone is continued for three or four weeks the total leucocyte count returns to normal, due to increase in the number of polymorphs, although the lymphocyte count remains low.

The present communication deals with the effect of cortisone on the antibody-level in the serum, the serum γ-globulin-level being taken as the measure of the antibody-level, since most antibodies are found in association with the γ-globulin fraction of the serum protein. In this investigation the γ-globulin-level was estimated by first separating the γ-globulin fraction by paper electrophoresis, then treating the electrophoretic paper with dyes and estimating the optical density of the protein dye complex by means of a photoelectric cell. In this manner the percentage of γ-globulin in relation to the total protein in the serum could be assessed.

Twelve male guinea pigs, aged about one year, were used for this investigation. Blood samples were first taken from each animal by heart puncture and the γ-globulin-level of normal serum estimated as described above. Each animal then received a daily dose of 10 mgm. of cortisone intramuscularly for five weeks, the blood samples were taken at weekly intervals and the γ-globulin-level of the serum estimated. More than forty estimations of this kind were made during the five weeks of cortisone treatment.

In all the animals the γ-globulin level became markedly reduced during the first two weeks of the cortisone injections and thereafter remained at a low level. In two of the animals, however, it increased slightly during the fourth and fifth weeks. These findings are in agreement with Bjørneboe, Fischel and Stoerk[3], who showed that cortisone inhibits the production of antibodies during active immunization and also after immunization is well established. They are also in line with the other blood changes recorded by Nicol and Bilbey[2]. Further, they emphasize the profound depression of the body defences produced by cortisone, and the great necessity to protect patients from intercurrent infection especially during the early stages of cortisone therapy.

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Action of Ribonuclease on the Multiplication of the Influenza Virus

Recent work of Ada and Perry[1] on the nucleic acid composition of influenza virus has shown that the infectious particles lack deoxyribonucleic acid, and that they contain about 0·8 per cent of ribonucleic acid. The degree of infectiveness is, in fact, a function of the ribonucleic acid content; the 'incomplete' form of the virus is characterized by a low infectivity/hæmagglutination ratio, and its ribonucleic acid content is lower than that of the standard form[2].

Indirect evidence for the importance of nucleic acid in the virus constitution is also given by the inactivation curve of virus infectivity by ultra-violet light; maximum effect is obtained[3] at a wave-length of 2652 A.

In the case of the tobacco mosaic virus, Casterman and Jeener[4] have observed a marked inhibition of synthesis of the virus by ribonuclease. The present work was undertaken with the hope of further defining the role of ribonucleic acid in virus growth, by studying the inhibitory action of ribonuclease on the multiplication of influenza virus.

Virus of strain *PR8* was cultivated in the allantoic cavity of the embryonated egg, or in test-tubes on a fragment of chorioallantoic membrane suspended in 1 ml. of diluted Hanks solution (method of Tamm *et al.*[5]). The hæmagglutinating power was assayed with chicken red-blood cells, by serial dilution of the culture medium. The infectivity was estimated by the method of Reed and Muench[6], after inoculation of embryonated eggs.

The enzymatic activity of the ribonuclease (G.B.I. or Armour) in the culture medium corresponded to concentrations of 0·1–0·7 mgm./ml. Tubes containing oxidized (inactive) ribonuclease served as controls. The following results have been obtained.

(1) The presence of ribonuclease in the culture medium inhibits completely the synthesis of the influenza virus cultivated on fragments of chorioallantoic membranes. In the controls, the hæmagglutinating titre rises regularly during incubation.

(2) Ribonuclease added to the culture medium at various times after introduction of the virus inhibits

Table 1. Treatment by Ribonuclease at Various Times after Infection by the Virus

Time between virus and ribonuclease injections	Hæmagglutinating titres, after incubation for 24 hr. at 37° C. Controls	Treated
(a) In vivo		
− 30 min. (before)	$10^{3\cdot1}$	$10^{0\cdot6\pm0\cdot3}$
+ 3 min. (after)	$10^{3\cdot0}$	$10^{0\cdot6\pm0\cdot3}$
+ 60 min.	$10^{3\cdot0}$	$10^{1\cdot6\pm0\cdot5}$
+ 2 hr.	$10^{3\cdot4}$	$10^{3\cdot1}$
+ 6 hr.	$10^{3\cdot2}$	$10^{3\cdot3\pm0\cdot1}$
(b) In vitro		
0 hr.	$10^{3\cdot9}$	$10^{0\cdot6\pm0\cdot3}$
+ 1 hr.	$10^{3\cdot6}$	$10^{1\cdot6\pm0\cdot2}$
+ 2 hr.	$10^{3\cdot3}$	$10^{2\cdot7\pm0\cdot3}$
+ 4 hr.	$10^{3\cdot7}$	$10^{2\cdot5\pm0\cdot3}$
+ 6 hr.	$10^{2\cdot8}$	$10^{2\cdot6\pm0\cdot2}$

virus multiplication, but only within the first two hours after infection. The same experiment with the chick embryo gives similar results: the enzyme (0·1 ml. of an 8 mgm./ml. solution) was injected into the allantoic cavity at various times after the virus had been injected (Table 1).

(3) Fragments of chorioallantoic membrane treated during 1 hr. with ribonuclease, and then well washed in saline at 37° C., support the growth of hæmagglutinating particles, but there is a lag-time of about ten hours.

(4) A good correlation has been observed between infectivity and hæmagglutinating power: the hæmagglutination titre can thus be considered as proportional to the number of active virus particles.

The following hypotheses may be considered in order to explain the facts.

(*a*) Ribonuclease acts directly on the ribonucleic acid of the particles, before they enter the cells of the membrane. This hypothesis can be discarded at once, since a suspension of influenza virus treated with ribonuclease, and then purified by adsorption on and elution from red blood cells, keeps its agglutinating and infective powers intact.

(*b*) Ribonuclease prevents the adsorption on, or penetration of the virus into, the host cells. This explanation is unlikely; the multiplication of the virus is not affected when the chorioallantoic membrane is infected with the virus in the presence of ribonuclease and washed after 1 hr. Adsorption and penetration of virulent particles are thus not prevented by the enzyme.

(*c*) Ribonuclease alters the metabolism of the host cell and thus prevents the synthesis of the virus.

In order to test this last hypothesis, the following experiment has been carried out: phenylalanine-^{14}C was added to fragments of the membrane previously treated with oxidized or reduced ribonuclease; no difference was found in the specific radioactivity of the proteins. The turnover-rate of the proteins is thus not affected by the ribonuclease The incorporation of adenine-^{14}C, on the contrary, is much reduced in membranes treated with the active enzyme. Further experiments are needed in order to decide whether this inhibition is correlated with a decrease in ribonucleic acid turnover. However, this inhibition of adenine incorporation into membranes treated with ribonuclease cannot entirely explain the inhibitory action of the enzyme on virus growth, since such membranes are still capable of supporting virus synthesis.

In conclusion, ribonuclease, in the reduced state only, prevents synthesis of the influenza virus provided that it acts during the first two hours after infection, that is, during the beginning of the lag period. It does not act directly on the ribonucleic acid of the infectious particles, and it does not prevent their adsorption on and penetration into the host cells.

A possible explanation of our findings is that the influenza virus separates into ribonucleic acid and protein when it penetrates into the cell, as has already been suggested for other viruses; in this free state, the virus ribonucleic acid might be sensitive to ribonuclease. If so, ribonucleic acid has essentially the same function in the influenza particle as deoxyribonucleic acid in the bacteriophages, and it might thus be responsible for genetic continuity.

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Incorporation of Adenine and Uracil into Ribonucleic Acid during Enzyme Induction in Resting Yeast

Spiegelman *et al.*[1], Pardee[2] and Creaser[3] have shown that purine or pyrimidine analogues inhibit induced enzyme formation in various micro-organisms. This strongly suggests that synthesis of nucleic acid is necessary for the formation of adaptive enzymes. Gale and Folkes[4] have shown that incorporation of uracil into ribonucleic acid is increased during induced formation of galactosidase in disrupted *Staphylococcus*.

Similar results have been obtained in our laboratory. We have observed an increased incorporation of labelled adenine and uracil into ribonucleic acids during the induced formation of cytochrome *c*[5], cytochrome peroxidase and catalase[6] in resting yeast (strain 'petites colonies').

The formation of these proteins is induced by oxygen in cells grown anaerobically. The mutant 'petites colonies' never acquires a functional respiratory system, and shows no Pasteur effect. In this strain, oxygen acts merely as an inducer of catalase, cytochrome *c* and cytochrome peroxidase; it is not consumed and cannot be involved in any energy-producing system[5].

The 'petites colonies' mutant was grown anaerobically, the cells washed with water and resuspended in a medium containing glucose, potassium acid phosphate and magnesium sulphate, but without a source of nitrogen or growth factors. They were incubated again for 1 hr. under anaerobic conditions. 8-^{14}C-adenine or 2-^{14}C-uracil was then added to the suspension; one half was shaken in the air, the other under anaerobic conditions. Samples were mixed with 10 per cent trichloracetic acid, the sediment was

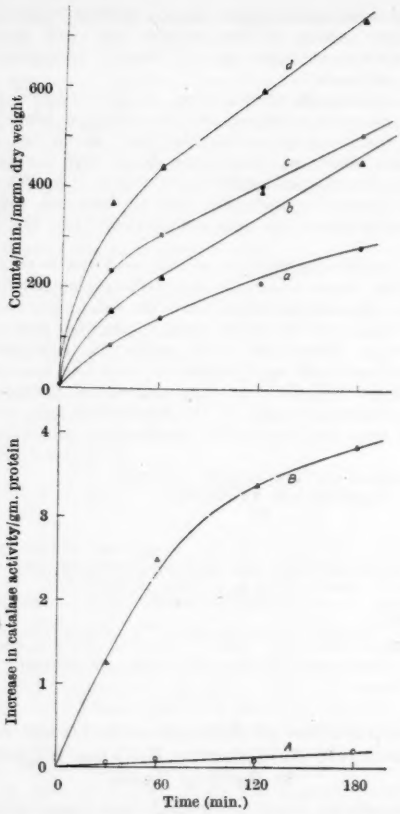

Fig. 1. Incorporation of radioactive carbon from uracil (curves *a* and *b*) and from adenine (curves *c* and *d*) into acid-insoluble compounds. Curves *A* and *B* show the increase in catalase activity per gm. of cell protein. *A*, *a* and *c* are the controls; *B*, *b* and *d* the induced cells

thoroughly washed to remove all acid-soluble compounds, plated, and its radioactivity measured.

The results of such an experiment are shown in Fig. 1. The incorporation of radioactive carbon from adenine or uracil is considerably increased during the induction of the enzyme.

On the other hand, when the same yeast strain was grown under aerobic conditions, it contained large amounts of catalase, which did not increase on further shaking in air. In this case, the rate of incorporation of adenine into nucleic acids was the same under anaerobic conditions as in the air.

The purine bases and the pyrimidine nucleotides liberated by hydrolysis of the nucleic acids were isolated by chromatography. When 8-^{14}C-adenine was added to the yeast suspension, both purines were labelled; when 2-^{14}C-uracil was added, both pyrimidine nucleotides contained radioactive carbon. The specific activities of the four components increased simultaneously during the induction of the enzymes. However, the relative increase was greater for guanine than for adenine, and greater for cytidylic acid than for uridylic acid.

The purines (adenine, guanine, hypoxanthine) from acid-soluble compounds have also been isolated. Their specific activities decreased more rapidly during adaptation than in the control.

It appears from my results that an increased synthesis, or a modification, of nucleic acids is associated with enzyme induction. One may conclude that ribonucleic acid is involved, because the induction increased the incorporation of uracil into the uridylic nucleotide obtained from nucleic acids.

The increased incorporation of adenine caused by the inducer is observed even when enzyme formation is blocked by *p*-fluorophenylalanine. According to Halvorson and Spiegelman's results[7], this analogue inhibits amino-acid utilization for protein synthesis in yeast. It may be concluded that the increased incorporation of adenine does not depend on the actual formation of any new enzyme system. The modification or synthesis of nucleic acid may be a condition for synthesis of induced enzyme; it is not a consequence of the formation of new enzyme molecules.

Ammonium sulphate fractionation of a yeast extract at *p*H 6 gave several fractions containing ribonucleic acid. The specific activities of both adenine and guanine of the different fractions differed considerably, and the percentage increase in specific activity due to enzyme induction was different for each ribonucleic acid fraction. This makes it very probable that the effect observed does not reflect any general change in ribonucleic acid metabolism, and that it involves certain specific nucleic acid fractions which will eventually be isolated.

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Response of the Sheep to Sublethal Doses of Fluoroacetate

As part of a study of the capacity of the sheep to metabolize lower fatty acids, the effect of continued administration of sublethal doses of fluoroacetate is being investigated.

Contrary to reports of the action of fluoroacetate on other animals[1], we have found that for sheep its toxicity is profoundly influenced by the route of administration and by the nature of the fodder.

Sodium fluoroacetate (2 mgm. daily) was administered to adult merino sheep (40–50 kgm. bodyweight) as follows: 1 mgm./20 ml. water as a drench twice daily, or 1 mgm./5 ml. water as a subcutaneous injection twice daily; 2 mgm./litre of water/day dripped continuously into the abomasum through a fistula; or 2 mgm./litre 0·9 per cent saline/day dripped continuously either into the peritoneal cavity or into the jugular vein. Three groups of animals that were treated in these ways were provided respectively with rations comprised of (*a*) 800 gm. wheaten chaff, (*b*) 800 gm. lucerne chaff, or (*c*) 800 gm. wheaten chaff plus 100 gm. gluten. The concentration of citrate in the blood was determined[2] at regular intervals during treatment.

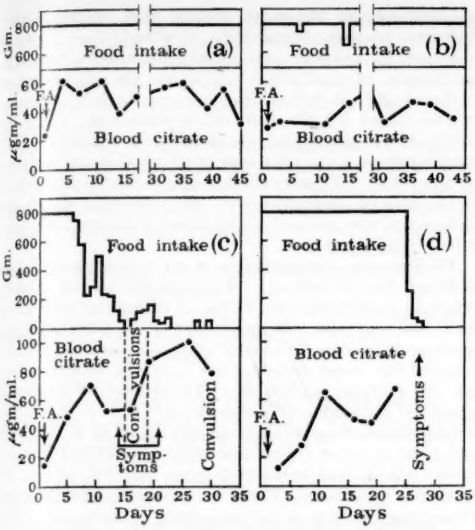

Fig. 1. Food intake and blood citrate-levels of four sheep receiving fluoroacetate. (*a*) Lucerne chaff diet, fluoroacetate drenched; (*b*) wheaten chaff–gluten diet, fluoroacetate drenched; (*c*) wheaten chaff diet, fluoroacetate drenched; (*d*) lucerne chaff diet, fluoroacetate via abomasal fistula

Sheep fed wheaten chaff developed symptoms when fluoroacetate was administered by any of the above routes. Failure to eat the full ration after seven to ten days of treatment and an almost total loss of appetite after twelve to eighteen days were constant features. Some died after a few days of treatment, apparently from heart-block; in the others, muscular inco-ordination and body tremors appeared after fourteen to eighteen days of treatment and culminated in periodic tetanic convulsions of short duration that continued until death ensued a few days later. During this latter stage, the animals that refused all but a small fraction of the ration wheaten chaff readily ate a full ration of lucerne chaff when this was offered, and eventually recovered despite the continued administration of fluoroacetate.

Those on the lucerne chaff ration continued to eat the whole of it and showed no symptoms for periods up to forty-five days, provided the fluoroacetate was administered by drench or by subcutaneous injection. When administered by intravenous injection or via an abomasal fistula, however, death occurred within ten to twenty days, and was not preceded by the characteristic syndrome shown by the animals that were maintained on the wheaten chaff ration: they consumed their ration until a day or so before death and showed no sign of tetanic convulsions.

The group fed wheaten chaff and gluten maintained their appetite and evidenced no symptoms for periods up to forty-five days, during which fluoroacetate was administered either as a drench or a subcutaneous injection.

Three animals in which rumen fistulæ had been established were fed on wheaten chaff, and a supplement of 20 gm. of acetic and 20 gm. of propionic acids adjusted with sodium hydroxide to *p*H 5·5 was introduced each day into the rumen. This supplement, however, did not prevent the symptoms. The sequelæ were identical with those that appeared when wheaten chaff alone was fed.

The symptoms were not closely correlated with the concentration of citrate in the blood. Some animals on wheaten chaff became convulsed during periods when their blood contained 50γ of citrate/ml., whereas others were apparently normal when their blood contained up to 80 γ/ml.

The animals consuming the lucerne rations did not become convulsed after treatment with fluoroacetate *per os*, although the citrate concentrations in their blood rose to 60 γ/ml.

The response of typical animals to treatment with fluoroacetate is indicated in Fig. 1.

The effects of lucerne or of a supplement of gluten suggests that protein may protect the ruminant against sublethal doses of fluoroacetate. Investigations are being continued.

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Length of the Muscle Fibres of the Rat Diaphragm

Since its introduction in 1946[1] the phrenic nerve diaphragm preparation from the rat has become one of the most commonly used mammalian nerve–muscle preparations in experimental research. Although indirect stimulation is most often employed, direct stimulation of this preparation has been increasingly used in recent years.

The general opinion is that the directly evoked muscle impulse arises at the cathode and runs along the entire length of the muscle fibre. It cannot, however, traverse the boundaries of the muscle fibre in which it is set up.

When the stimulating electrodes span the entire muscle, all the fibres of the muscle may respond if the current density is high enough to stimulate each fibre individually. With stimulation at one end, however, the response depends on the proportion of the length of the muscle fibres to the length of the muscle, and the whole muscle reacts only if the fibres run the whole length of the muscle[2]. When direct stimulation is applied, it is important to know how great a fraction of the muscle is actually stimulated. Consequently, knowledge of the length of the muscle fibre is valuable. According to Brown and co-workers[3], the length of the single fibres of the rat diaphragm does not exceed 5 mm.

Hajdu and Knox[4] have shown that end-plate potentials can be most easily recorded from a narrow zone midway between the central tendon and the ribs transversely to the fibre direction. That the end plates are actually localized in this zone with a rather small scatter is easily shown by means of histochemical technique. On stimulating fully curarized preparations either at one end or all over, we have been surprised by the often negligible difference in the height of contractions elicited (Barstad, unpublished work). It therefore seems open to question whether the fibre-length can be limited to 5 mm.

We have tried to elucidate the problem by means of histological as well as electrophysiological technique. Rat diaphragms were cut into strips 5–10 mm.

broad, parallel to the fibres, from the costal insertion to the central tendon. The strips were placed in a saturated aqueous solution of sulphur dioxide[6] at room temperature for eight to fourteen days. They were heated in distilled water to boiling point and then immediately cooled to room temperature. This procedure was carried out four or five times.

After blunt dissection, entire single fibres were isolated with the aid of a binocular of magnification 20. The fibres, both unstained and stained with Heidenhain's hæmatoxylin, were studied under a microscope. The transverse striation was easily observed in all cases.

Twenty single fibres from rat diaphragms were successfully isolated in this way. In each case the fibre could be traced continuously from the costal margin to the central tendon. A greater number of fibres were broken up into two or three parts during dissection. It thus seems very probable that at least some of the fibres run the whole length of the muscle.

To supplement these findings we recorded action potentials from completely curarized isolated rat-diaphragm preparations that were stimulated by electrodes at the costal insertion of the muscle. Square wave pulses with a frequency of 10 per min. and a pulse width of 0·6 m.sec. were supplied by an electronic stimulator with an output of 75 m.amp.

Despite a troublesome shock artefact, it was possible to record potentials close to the central tendon. The decrease in action potential in the tendinous part of the muscle was roughly parallel to the decrease in the proportion of muscle tissue in this part of the preparation as shown in cross-sections stained with hæmatoxylin and eosin.

This finding also indicates that at least a considerable number of the muscle fibres run the whole length of the muscle.

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A Radiographic Method for the Study of the Function of the Cow's Udder

In studying the function of the milk gland, with the view of increasing milk production, particular attention has been devoted in recent years to the milk-ejection mechanism (the let-down reflex). Ely and Petersen[1] demonstrated the important part played by oxytocin in milk ejection; Grachev[2] and Barishnikov *et al.*[3] emphasized the influence exerted by the central nervous system.

In almost all the reports available, the methods of studying the let-down reflex have been based upon catheterization of the udder and the measurement of changes in pressure within the udder during different phases of milking. Contradictory findings obtained in this way may be attributable to variation in details of technique, such as the diameter of catheter used, depth of insertion, or possibly irritation of the udder by the indwelling catheter.

We have attempted to develop a method which would permit objective registration of motor activity in the udder. This method consists of demonstration by X-rays of changes within the collecting ducts and cisterns of the udder by means of a contrast medium filling this system.

Preliminary experiments were carried out using isolated cow's udders. The suitability of various contrast media, the technique of filling the milk ducts and cisterns, and the amounts of medium required were worked out. 'Ultraren' (aqueous iodide solution) proved the most satisfactory contrast medium, and 20 ml. sufficed to display the cistern of one milk gland of an udder of average size.

The method was then tested in a cow (No. 80, red spotted breed) with low milk production (3 litres daily) which had recovered from mastitis of the left posterior quadrant. Tests were preceded by a period of acclimatization to experimental conditions. Thus, the cow was accustomed to the X-ray room, gradual darkening of the room, the sound of the X-ray apparatus, etc., by being milked under identical conditions at the same time daily. She seemed entirely accustomed to the experimental environment after ten days. Adaptation was considered complete when the milk yield in the X-ray room equalled that obtained under normal conditions in the cow-shed.

Preparation for radiographic study was then carried out as follows. The tip of the teat was gently wiped, and a fine sterile rubber catheter introduced. A 'Nelaton' catheter No. 2 was used, dipped in 'Pateol' (urological antiseptic lubricant). The procedure caused no defensive reaction in the cow. About 20 ml. of milk was allowed to drip from the catheter, 20 ml. of contrast medium was slowly injected, and the catheter withdrawn. A 35 per cent solution of 'Ultraren', heated to 37° C., did not seem to cause any irritation of the udder, as evidenced by no change in radiographic appearance. The following is a brief report of some of our observations made using this method.

After mechanical stimulation of the teat filled with contrast medium, such as squeezing several times as in milking, contractions of the distal portion of the cistern, most marked in the central section of the teat, appeared within a few seconds. The shadow, initially of smooth cylindrical shape, developed an hour-glass constriction.

If a teat on the opposite side of the udder was similarly stimulated, contraction occurred after a delay of about one minute. Contractions were periodic and continued for about 15 min. The duration of each contraction was 7–15 sec., their frequency 1–2 contractions a minute. With contractions, the contrast medium was forced to the roof of the cistern, and after several contractions reached the larger milk ducts. It was possible to demonstrate that this was not merely due to simple diffusion of the contrast medium.

The relationship between contraction of the cisternal smooth muscle and milk ejection evoked by administration of oxytocin was also investigated. It was found that intravenous injection of oxytocin in dosages sufficient to cause milk ejection was not associated with contractions as described above.

The effect of squeezing the teat during milking was also noted. Following such squeezing of the base of the teat at the beginning of milking, the contrast material was observed to rise in the cistern and spurt into the milk ducts, as in isolated udder preparations.

On the basis of these preliminary observations, we believe this method is a promising one for investigation of the motor function of the udder, and hope in future investigations to re-assess current theories as to the nature of this process.

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Region *E* and the S_q Current System

The equilibrium equation for the electron density N in a solar-controlled ionospheric region, such as normal region E, is, with the usual nomenclature:

$$\frac{\partial N}{\partial t} = q_0 \cos\chi - \alpha' N^p - \mathrm{div}(N\mathbf{v}) \qquad (1)$$

where χ is the solar zenith angle, α' the effective recombination coefficient and $\mathbf{v}$ the vector drift velocity; q_0 is proportional to the intensity of the solar ionizing radiation. The solution of this equation has been discussed by Martyn[1] and by Appleton and Lyon[2]. At or near noon, $\partial N/\partial t \doteqdot 0$, and if the movement term $\mathrm{div}(N\mathbf{v})$ is small, the critical frequency fE is related in a simple manner to χ, and we can write:

$$(fE)^n = K\cos\chi \qquad (2)$$

K is a constant, $n = 2p$ and for an isothermal region has the value 4 for recombination and 2 for attachment. In practice, it is found that the values of n deduced from the approximate equation (2) usually lie between 2 and 4, and this has been interpreted by most workers as evidence for a height gradient in the effective recombination coefficient or non-isothermal conditions in the layer. An alternative approach, and one which we adopt here, is to suppose that the apparent variations in n with time and place may result at least partly from neglect of the movement term $\mathrm{div}(N\mathbf{v})$.

It is now generally believed that the S_q magnetic current systems are located at or near the level of region E, and Martyn[3] has shown that vertical drift may be expected to modify the electron density distribution at places where the current systems have east–west components. Such modifications will appear in fE and these in turn may influence the index n. Curve A in Fig. 1 shows average values of n deduced (by the method of least squares) from equation (2), using monthly mean noon values for the years 1952–54 for all available stations in a longitude zone centred approximately on the 150° E. meridian. For these years of low solar activity only minor corrections for changing month-to-month activity were necessary. It will be seen that there is a clear variation of n with latitude, with quite

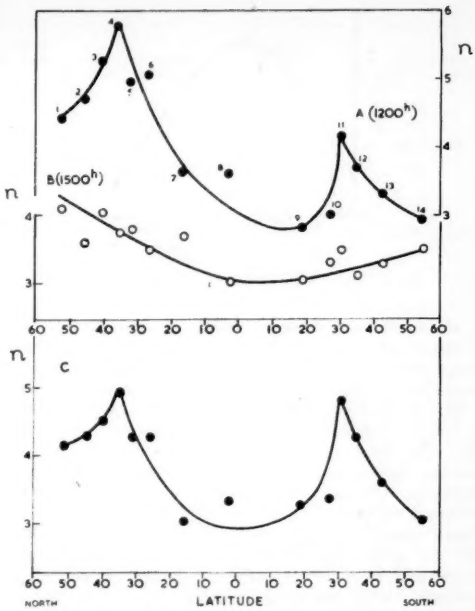

Fig. 1. Index n for stations centred approximately on the 150° E. meridian, derived from values of fE for 1952–54. Curve A: 1200 hr.; curve B: 1500 hr.; curve C: 1200 hr. reduced to common solar distance.

1, Adak. 2, Wakkanai. 3, Akita. 4, Tokyo. 5, Yamagawa. 6, Okinawa. 7, Baguio. 8, Singapore. 9, Townsville. 10, Brisbane. 11, Watheroo. 12, Canberra. 13, Hobart. 14, Macquarie Island

marked singularities at or near Tokyo and Watheroo. These stations are situated near the mean latitudes of the foci of the S_q current systems, and it seems probable that the singularities in the curve are to be associated with the fact that the foci are overhead at approximately 1100 hr.

The values of n are a measure of the seasonal variation in fE, and depend quite markedly on any differential influence between seasons. In January the solar distance is some 3 per cent less than in July, and when the appropriate small corrections are made to the monthly mean values of fE to allow for this, the marked asymmetry in curve A is largely removed (Fig. 1, curve C). The small residual differences between stations in the higher northern and southern latitudes may possibly be due to the magnetic asymmetry of the Earth.

We have made a similar study for two other longitude zones (centred on 10° E. and 70° W.) and find confirmatory evidence for these singularities north and south of the equator. Now magnetic studies show that, in summer, the current systems are much stronger than in winter, and also that the foci are then some 10° nearer the equator. At the foci, no vertical drift will occur; at higher latitudes (current towards the west) drift will be downwards, and at lower latitudes (current towards the east) drift will be upwards. Martyn and also Appleton and Lyon have shown that the changes in electron density to be expected as a consequence of vertical drift depend on both the velocity of drift and on the height-gradient of this velocity. If downward drift is associated with a decrease in fE, and vice versa, then an explanation for the marked peaks in n near latitudes 35° N. and 30° S. can be formulated

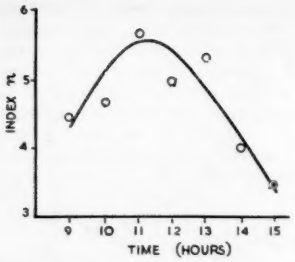

Fig. 2. Index n for various hours at Tokyo (1952–54)

in terms of vertical drift assuming that, with change of season, the foci of the current systems move north–south across these latitudes and the current intensity varies in the manner indicated by magnetic studies[4].

The S_q current system moves around with the Sun, and near 1500 hr. at all latitudes less than about 70° the east–west component is very small, so that vertical drift effects may also be expected to be much reduced. We have calculated the index n from the seasonal variation in fE at 1500 hr. at all stations. These values are shown in Fig. 1, curve B, and it will be seen that they are generally less than at noon, and that at this hour no peaks appear at any latitude. This remarkable change between 1200 and 1500 hr. tends to confirm that our interpretation of Fig. 1, curve A, is probably valid. Moreover, when the influence of the current systems is removed, there appears to be a gradual decrease in n towards the equator. This may be evidence for a change in E-layer characteristics (such as vertical temperature gradient) from temperate to equatorial latitudes.

For certain stations we have also calculated the index n for each hour between 0900 and 1500, and the values found for Tokyo are plotted in Fig. 2. In these calculations the appropriate corrections for the equation of time and varying sunspot number and solar distance have been made. It will be seen that the variation over the day is markedly asymmetric, forenoon values being considerably larger than those at corresponding afternoon times, and the peak value is not at noon but at about 1100 hr. This type of variation is just that to be expected, since the east–west component of the S_q current system, and hence vertical drift effects, are a maximum an hour or so before noon.

If 'normal' values of fE (that is, those unaffected by S_q effects) occur when the focus is overhead, we can estimate the approximate order of magnitude of the change in region E ionization at various latitudes as a result of vertical drift. For the latitude of Tokyo, our results suggest that in June and December the peak ionization density is respectively decreased and increased by some 3–4 per cent, whereas at the equator the corresponding increase seems to be about 10 per cent. It is to be emphasized that the fE perturbations involved are very small and these figures are only approximate indications of the orders of magnitude. However, the experimental results certainly indicate a marked increase in vertical drift effects towards the equator, a conclusion which is in accordance with theoretical considerations.

A more extended study shows that region E exhibits a number of departures from a Chapman-type layer, and it is now clear that these are largely, if not entirely, to be explained in terms of vertical drift.

We have made a similar study of n for region $F1$, and find that although there is some evidence for anomalous values near the latitudes of the current foci, there are no sharply defined maxima of the kind found for region E. A more detailed discussion of these and other results will be published elsewhere.

The above work was carried out as part of the programme of the Radio Research Board of the Department of Scientific and Industrial Research, and this is published by permission of the Director of Radio Research.

Note added in proof. Appleton *et al.* have recently published (*Nature*, **176**, 897; 1955) a description of work which provides other ionospheric evidence for the influence of the S_q current system in region E.

W. J. G. Beynon
G. M. Brown

Department of Physics,
University College of Swansea. Oct. 6.

[1] Martyn, D. F., *Proc. Roy. Soc.*, A, **189**, 241 (1947).
[2] Appleton, E. V., and Lyon, A. J., Phys. Soc. Conference on "The Physics of the Ionosphere", 20 (1955).
[3] Martyn, D. F., *Phil. Trans.*, A, **246**, 281 (1953).
[4] Chapman, S., and Bartels, J., "Geomagnetism", 229 (1940).

Determination of the Thickness of Ice Shelves by Seismic Shooting Methods

Seismic soundings of the thickness of the floating ice shelves of Antarctica have so far been attempted by two expeditions, the Second Byrd Antarctic Expedition of 1933–35 [1], and the Norwegian–British–Swedish Antarctic Expedition 1949–52 [2,3]. Further measurements are likely to be made by several expeditions during the International Geophysical Year 1957–58.

Reports which have appeared to date do not give a satisfactory interpretation of the detailed recordings. The reasons for rejecting Poulter's earlier interpretation[1], which assumed that sea water percolates through ice shelves to sea-level, have already been outlined[2]. My preliminary report[2] used an empirical method, based on the known thickness of ice at one station, to interpret the travel times of echoes at other stations in terms of thickness, as the detailed interpretation of the echoes was not clear. This method indicated that the ice shelves were of almost uniform thickness, a result which appeared to fit one's experience of these features.

Now that a detailed study of the results has been made, this picture has proved to be inconsistent with various related observations. A new and consistent interpretation of the results is therefore proposed.

The major inconsistency found was the lack of agreement of ice thickness with the surface height of the ice shelves. These heights proved to be more accurate than originally anticipated, the standard deviation for ten measurements at different times for a station at 115 km. from Maudheim being 3·3 m. The variation of surface height with the preliminary estimates of ice thickness shown in Table 1 could only be explained by large variations in the mean density of the ice shelf with location. Poulter has actually used his results to make such deductions. However, detailed interpretation of the seismic velocity–depth curves shows that depth–density profiles in Queen Maud Land do not vary rapidly with location. Assumptions such as varying rock loads carried at the bottom of the ice fail to satisfy the density variation which would be needed to correlate surface heights with the preliminary estim-

Table 1

Station No.	Surface height (m. above sea-level)	Thickness of ice shelf (a) Prelim. estimate (m.)	Thickness of ice shelf (b) Present estimate (m.)	Mean density (new estimate)	Thickness of water layer (m.)	Depth of sea-bed (m. below sea-level)
178	37	185*	210	0·84	285	455
172	56	(169)	407	0·88	206	555
170	64	(192)	484	0·89	363	779
169	70	(199)	504	0·88	624	1,054
167	71	(194)	{544† 492†	0·89	99	572

* Based on ice and firn density measurements on core samples at Maudheim, which give mean density 0·82.
492 m. is the depth to the first reflecting surface in the ice, probably due to moraine material, and 544 m. is the approximate depth to water.

Table 2. Arrival Times of Echoes on Ice Shelves (in milliseconds) after Explosion Time

Station No.	Ice-water interface								Sea bottom	
	P Seismometer*		*PS*		Double *P*		Triple *P*		*P*	
	No. 1	No. 6	No. 1	No. 6	No. 1	No. 6	No. 1	No. 6	No. 1	No. 6
178	(130)	(132)	—	—	254	256	376	377	520	522
172	231	233	—	—	—	—	—	—	514	517
170	271	273	407	416	539	540	—	—	772	774
169	281	284	—	—	563	564	—	—	1.143	1,145
167	274	276	—	—	537	538	—	—	429	431

* Seismometers 100–150 m. from shot point.

ates of thickness. In addition, mean densities necessary for such correlation would not fit the values obtained by Schytt[4] at Maudheim to a depth of 100 m., as do the new mean densities shown in Table 1.

In order to interpret the results in a way consistent with the surface height observations, it is necessary to assume that we have been dealing with the second reflexion of a *P* wave at station 178, but with the first reflexion of the *P* wave at the other four stations. The arrival times of the main reflected pulses are shown in Table 2, tabulated according to the new interpretation. The pulse now interpreted as being the *PS* phase at station 170 was originally assumed to be the same as the triple reflexion of the *P* wave at 178, and was considered to favour the preliminary method of interpretation. Confirmation as to whether or not this is the *PS* phase could be obtained by future workers measuring the horizontal component of motion, which should be much larger than the vertical component for short spreads such as we used. Both the vertical component of amplitude in relation to that of the *P* wave reflexion and the mean arrival time of this pulse are of the correct order for the *PS* phase, but, as the spread of arrival times over the six seismometers appears to be about double that calculated, some doubt remains.

Another check on the new interpretation is provided by working out the reflexion coefficient for the energy reflected by the ice-water interface after making allowance for attenuation of the *P* waves. This has been done by measuring the amplitude of successive multiple reflexions, and agreement with the theoretical value is much closer than that provided by the preliminary figures. Finally, a pulse on the records at 178 has been recorded which arrives in the middle of the Rayleigh waves and is apparently the first *P* reflexion at this station. The clarity of the pulse was not sufficient to be taken as an echo on its own merits, but in view of the foregoing it is now assumed to be the first reflexion.

The revised interpretation of the results is shown in Fig. 1. Full use has been made here of the surface heights of the ice shelves in order to estimate changes in ice thickness.

The idea of an approximately constant equilibrium thickness of ice shelves of about 200 m., which was expressed in the preliminary publications, is not correct. It still appears likely that an approximate equilibrium thickness is maintained at a given locality, as indicated by surface levelling at different times at Maudheim, but this 'equilibrium thickness' obviously varies with position. Consequently any equation relating accumulation and spreading of ice sheets must also take into account variations of thickness as the ice shelf moves forward.

The proposal that 'ice hills' form where there is insufficient depth of water to float an ice shelf, which would otherwise be expected to be present, fits the new interpretation of observations still more closely than the earlier interpretation.

As regards the section of the profile over which the ice was resting on rock, no significant changes in

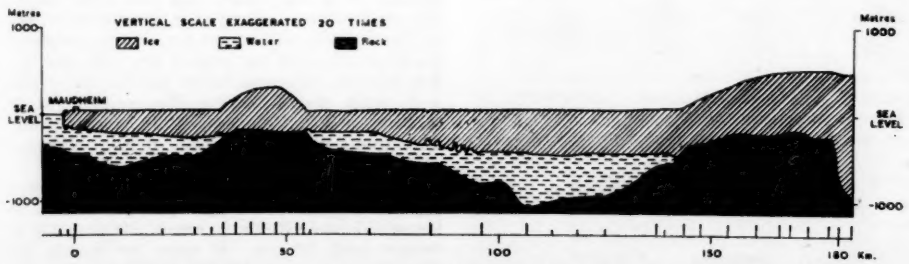

Fig. 1. Main seismic profile. The long vertical lines above the distance scale show points at which echoes were obtained from the bottom of the ice, while the short lines indicate points at which echoes were recorded from the sea bottom only

interpretation from the preliminary publications have resulted from the more detailed study.

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Dec. 23.

[1] Poulter, T. C., "Geophysical Studies in the Antarctic" (Stanford Research Institute, California, 1950); *Trans. Amer. Geophys. Union*, **28**, No. 2, 162 (1947); **28**, No. 3, 367 (1947).
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Control of the Staining Procedure after Paper Electrophoresis

When quantitative techniques are attempted for the analysis of serum proteins separated by electrophoresis on filter paper, it is recognized that the staining procedure, followed by removing the surplus stain, constitutes sources of error. In order to get more satisfactory reproducibility we apply on each paper strip (after electrophoresis but before staining) 0·02 ml. of a 0·05 per cent solution of polyethylenimine (Badische Anilin und Sodafabrik, Ludwigshafen (Germany)) in water. This polybase, —[—CH_2—CH_2—NH_2—]$_n$—, has the advantage of being stained by naphthalene black 12 *B* as well as by sudan black; therefore it can be used equally well as a reference substance for protein staining and lipoprotein staining. The molecule (mol. weight approx. 30,000–40,000) of the polybase (called 'Polymine') is of linear build and possesses such an affinity for cellulose that the stained spots cannot easily be eluted but must be estimated by direct-reading colorimetry. The paper strip *a* (see Fig. 1) shows the separation of normal serum proteins (Whatman paper No. 1, *p*H 8·6, 10 V./cm.) and a spot of 0·02 ml. 'Polymine' standard on each side. Strip *a* has been stained with naphthalene black and strip *b* with sudan black. It is well known that in pathological sera the uptake of dyes is variable; in such cases the 'Polymine' standard can serve as a reference because the solubility interrelationships between dye, solvent and polybase are constant.

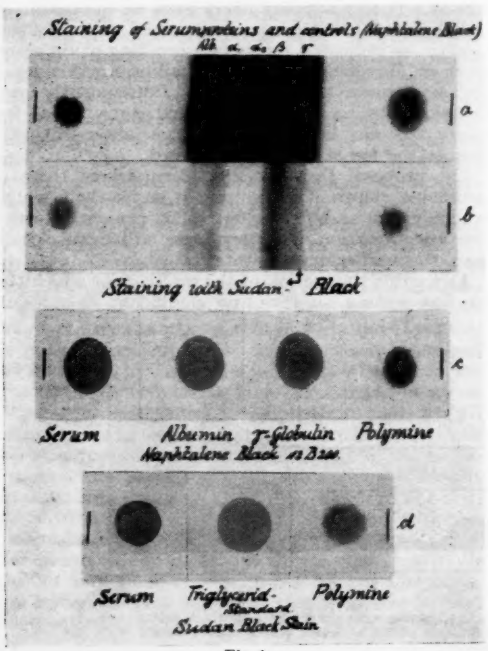

Fig. 1

Table 1

	Volume (ml.)	Amount (γ)	Planimeter reading	First standard deviation
Stained with naphthalene black				
Serum, dil. 1 : 40	0·02	35	0·92	1·8
Albumin, human	0·02	30	0·90	1·7
γ-Globulin, human	0·02	30	0·83	1·6
'Polymine' (0·05 per cent)	0·02	10	1·00	2·0
Stained with sudan black				
Serum, dil. 1 : 1	0·02	150 (lipids)	1·25	1·7
Triglyceride-standard	0·02	80	1·20	1·5
'Polymine' (0·05 per cent)	0·03	15	1·00	2·7

On paper strip *c* the staining of some proteins with naphthalene black is compared with the staining of the 'Polymine' standard on the right. Paper strip *d* is stained with sudan black; in the middle section there is a drop of 0·02 ml. of triglyceride standard, containing 60 γ of triolein and 20 γ of tristearate, which we have used[1] as reference for lipoprotein staining. The spot on the left of it is a drop of 0·02 ml. of normal serum diluted 1 : 1 with sodium chloride (physiol.). The dye uptake of such a drop gives a fair measure of the total lipids of the serum. Table 1 shows the mean results of twenty-five spots of each substance, as read in the electronic densitometer Model 525 of the Photovolt Corp.

The different diffusion (spread) of the spherical colloids (proteins) and the linear colloid ('Polymine') is noticeable.

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Nov. 28.

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A New Solvent for Quantitative Paper Chromatography of Sugars

Many mobile phases are found in the paper chromatography of sugars; but the separation of sucrose, fructose and glucose is somewhat difficult, because their R_F values are very near each other[1]. The separation is enough for identification purposes, but it is not good enough for elution or photometric readings, because the sugars are still partly mixed. The solvent suggested below divides the sugars quite well with the following R_F values (at 20° C.): sucrose, 0·17; glucose, 0·26; mannose, 0·30; arabinose, 0·32; fructose, 0·32; xylose, 0·33; ribose, 0·41.

The solvent, which was studied for non-volatile organic acids[2], is: normal propyl alcohol, 50 c.c.; benzyl alcohol, 72 c.c.; water, 20 c.c.; 85 per cent formic acid, 20 c.c. It must be freshly prepared. The photometric readings give with this solvent a graph of well-separated curves, so that errors due to the computation of common areas are eliminated.

It is preferable to evaporate the solvent with warm air before spraying with the reagent.

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[1] Lederer, M., and Lederer, E., "Chromatography", 158 (Elsevier Pub. Co., 1953).
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Ultra-Violet Absorption of Oxygen in Organic Solvents

IT has been found that, in a number of organic solvents, dissolved oxygen gives rise to absorption in the far ultra-violet. This absorption is completely eliminated when oxygen is removed by boiling, or by bubbling nitrogen or other gases through the solvent.

In Fig. 1 are shown spectra of cyclohexane at 30° C. in equilibrium with oxygen at several partial pressures. In the wave-length range studied, the absorbance due to oxygen is found to be directly proportional to the partial pressure of oxygen above the solution. Similar spectra have been obtained with *n*-hexane, *n*-heptane, methanol, ethanol and diethyl ether.

To determine whether the absorption might be due to free oxygen, the solubility of oxygen in cyclohexane was measured. At a partial pressure of one atmosphere, approximately 0·27 vol. of oxygen (reduced to standard temperature and pressure) dissolves in one volume of cyclohexane. The absorbance of an equivalent concentration of gaseous oxygen is negligible in the spectral range considered, so the absorption of the solution must be due to interaction between oxygen and the solvent.

Assuming that this interaction results in the formation of a molecular complex which is in turn responsible for the absorption, a reaction of the form $mO_2 + nS \rightleftharpoons (O_2)_m \cdot S_n$ with equilibrium constant $k = a_c/a_o{}^m a_s{}^n$ may be supposed to apply, where O_2 is oxygen, S is solvent, m and n integers, and a_c, a_o and a_s are the activities of the complex, oxygen and solvent respectively. For the activity of oxygen the partial pressure p may be substituted. Assuming, furthermore, that the solution is ideal and that Beer's law holds for the complex, a new equilibrium constant is found: $k' = D/p^m x^n$ (D is the absorbance at a given wave-length due to the complex, and x is the mole fraction of solvent).

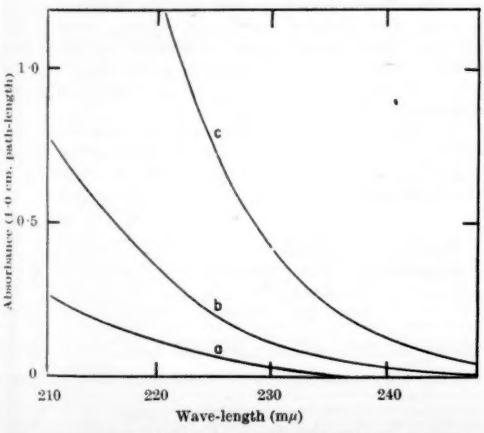

Fig. 1. [Spectra of cyclohexane in equilibrium with partial pressure, p, of oxygen: *a*, $p = 0$; *b*, $p = 0{\cdot}18$ atm.; *c*, $p = 0{\cdot}84$ atm.

As the solvent is present in large excess, x is essentially independent of p. Consequently, from the proportionality of D to p, one must conclude that $m = 1$.

The value of n was found by determining the dependence of absorbance on solvent composition, for a series of mixtures of cyclohexane and *n*-heptane at a given partial pressure of oxygen. The absorbance was considered to be the sum of the absorbances of the cyclohexane and of the *n*-heptane complexes, the contributions of each being governed by the separate equilibrium constants, k'.

As oxygen absorbs considerably less in *n*-heptane than in cyclohexane, although equally soluble in the two solvents, definite conclusions could be drawn only with regard to the latter. The results indicate that, for cyclohexane, $n = 1$; or, in other words, cyclohexane and oxygen form a 1 : 1 molecular complex.

This investigation was supported by a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth, National Research Council. One of us (J. F. S.) was a Scholar in Cancer Research of the American Cancer Society.

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Ectotrophic Mycorrhiza in Renantherous Species of *Eucalyptus*

THERE appear to be in the literature no detailed studies of mycorrhiza in *Eucalyptus*. Brief references are made by Samuel[1], in South Australia, and Smith and Pope[2], in South Africa.

It might be thought mycorrhiza plays no significant part in success or failure of *Eucalyptus* introductions since so many species have been successfully cultivated as exotics in numerous countries. While this is true of *Eucalyptus* as a whole, introduction records show that species of the group *Renantherae* are largely exceptional to this.

The failure of the *Renantherae* is striking when it is realized that they have been introduced on many occasions because they contain a larger percentage of good timber species than any other group of the genus. The situation is well illustrated by records from Cyprus. Chapman[3] lists twenty-one renantherous species in a total of about seventy introductions since 1878; but not one of them could be found growing on the island in 1953, although representatives from all other groups were found.

Table 1

	Heat-sterilized soil + *Scleroderma* spores			Heat-sterilized soil		
	Growth* (6 mths.) (in.)	Colour	Mycorrhiza	Growth* (6 mths.) (in.)	Colour	Mycorrhiza
Renantherae						
E. dives	5·3	Normal green	Abundant	3·2	Yellowish	Nil
E. pauciflora	6·2	Normal green	Common	3·3	Yellowish	Nil
E. macrorrhyncha	11·3	Normal green	Abundant	7·8	Yellowish	Nil
Macrantherae						
E. bicostata	9·5	Normal green	Nil	8·8	Normal green	Nil

* Average maximum growth in height. There were many seedlings per pot

The *Renantherae* have been found on genetic grounds to be a very distinct natural unit within the genus *Eucalyptus*[4]. They differ from the rest of the genus in many respects, and this led to the idea that their mycorrhizal requirements may also differ. Experience in Iraq in 1953 at the forest nursery at Eski Kellek supported this view. Here some eucalypts grew easily, and the plants were as healthy and vigorous as stock of a similar age grown under comparable conditions in Australia. Species of the *Renantherae*, however, raised there at the same time, were weak and chlorotic and mostly died. The particular species were *E. dives*, *E. pauciflora*, *E. robertsonii* and *E. fastigata*. Afterwards, in Australia, at Canberra, similar symptoms were induced in the same species by growing them in soil sterilized by heating. This effect is contrary to that commonly obtained using sterilized soil, as Stahl[5] demonstrated by his well-known experiments, and indeed his results apply to most *Eucalyptus* species other than the *Renantherae*.

Trials were continued to test the idea that lack of mycorrhiza was responsible for failure. Three species of the *Renantherae*, *E. dives*, *E. pauciflora* and *E. macrorrhyncha*, were used and compared at the same time with *E. bicostata*, belonging to the group *Macrantherae-Normales*. Pot cultures using spores from fruiting bodies of the gasteromycete, *Scleroderma flavidum*, were made for comparison with plants in sterilized soil to which spores were not added. *Scleroderma flavidum* was chosen because its fruiting bodies are found closely associated with *E. pauciflora* and *E. robertsonii* in experimental plantations near Canberra. Spores were applied liberally ½ in. below the final surface and the pot was then filled up with more heat-sterilized soil so that the growing roots had to pass through the spore layer. After four months there were distinct differences, as shown in Table 1.

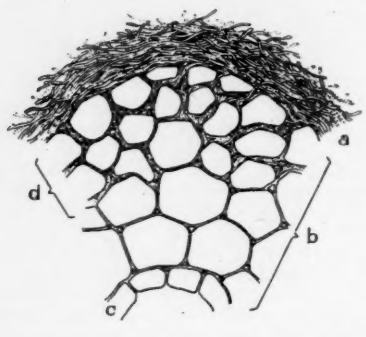

Fig. 1. Cross-section of a mycorrhiza of *E. macrorrhyncha* and *Scleroderma flavidum*, showing (*a*) hyphal mantle, (*b*) cortex, (*c*) endodermis, (*d*) Hartig net

Good growth and good colour in the *Renantherae* were accompanied by the development of mycorrhiza following the application of *Scleroderma* spores, whereas *E. bicostata* grew equally well with or without the spores and did not produce mycorrhizas. The mycorrhizas in the three renantherous species were clearly visible on the outside of the ball in the pot and consisted of a thick hyphal mantle and a coralloid branching habit characteristic of the ectotrophic mycorrhiza of some hardwoods. Microscopic examination of that on *E. macrorrhyncha* showed a dense, thick hyphal mantle outside the root epidermis with a distinct Hartig net penetrating to a depth of two or three cortical cells, and exhibiting a structure (Fig. 1) closely comparable with that of ectotrophic mycorrhiza figured by Björkman[6]. The experiment shows, therefore, that *Scleroderma flavidum* is able to form an ectotrophic mycorrhiza with three renantherous species and that these grow healthily in heat-sterilized soil if *Scleroderma* spores are added; but they do not form mycorrhizas and grow poorly in soil sterilized by heating if no fungus is added. While it is probable that ectotrophic mycorrhiza occurs in species in other groups of the genus, it seems clear that it is not essential for thrifty growth in these. The experiment and observations suggest that the failure or indifferent growth of many species of the *Renantherae* in the northern hemisphere may be corrected by inoculation with the appropriate fungus. Some of the best timber-producing species are renantherous, such as *E. regnans*, *E. fastigata*, *E. gigantea*, *E. pilularis*, *E. marginata* and *E. obliqua*.

There are reasons for thinking that the situation may differ in the southern hemisphere, and there are records of satisfactory growth of renantherous species in both New Zealand and South Africa. It may well be that there is a degree of affinity in the fungal flora of these three countries, as is the case with the higher plants, which leads to the presence of adequate mycorrhiza-forming fungi.

A more detailed account will be published elsewhere. I am indebted to Dr. Erwin Gauba for the microscopic preparation and to Mr. O. Ruzicka for the drawing.

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[1] Samuel, G., *Trans. and Proc. Roy. Soc. South Australia*, **50**, 245 (1926).
[2] Smith, N. J. G., and Pope, F. B., *Trans. Brit. Mycol. Soc.*, **19**, 95 (1934).
[3] Chapman, E. F., "The Cyprus Eucalypts" (1953).
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[6] Björkman, E., *Svensk. Bot. Tidskrift.*, **43**, 223 (1949).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, March 26

CHEMICAL SOCIETY (in the Great Hall, The University, Nottingham), at 9.30 a.m.—Symposium on "Antibiotics and Mould Metabolites".

PHARMACEUTICAL SOCIETY OF GREAT BRITAIN (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Dr. E. F. Hersant: "Analysis and the Pharmacist".

Tuesday, March 27

CHEMICAL SOCIETY (in the Great Hall, The University, Nottingham), at 10.45 a.m.—Prof. W. Wardlaw: "Alkoxides, Old and New" (Presidential Address).

BONE AND TOOTH SOCIETY (at the Institute of Orthopædics, 234 Great Portland Street, London, W.1), at 5 p.m.—Symposium on "Bone Tumours". Dr. A. D. Thomson: "The Classification of Bone Tumours"; Dr. C. H. G. Price: "Primary Osteogenic Tumours of the Skeleton and Their Relationship to Bone Growth and Metabolism"; Dr. H. A. Sissons: "Experimental Bone Tumours".

CHADWICK TRUST (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 5.30 p.m.—Dr. B. A. Southgate: "A Survey of Progress in the Control of Stream Pollution"* (Chadwick Public Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT and RADIO SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. E. Franklin and Mr. J. B. James: "The Applications of Transistors to the Trigger, Ratemeter, and Power Supply Circuits of Radiation Monitors".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. J. F. Harper: "The Rise of the Aircraft in Pest Control Agriculture".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. R. K. Sandiford: "Atomic Energy Plant Instrumentation".

Wednesday, March 28

CHEMICAL SOCIETY (in the Great Hall, The University, Nottingham), at 11 a.m.—Prof. Dr. Otto Hahn: "Personal Reminiscences of a Radiochemist" (Faraday Lecture).

BRITISH NUCLEAR ENERGY CONFERENCE (in the Lecture Hall, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1), at 3 p.m.—Symposium on "Nuclear Energy".

PHYSICAL SOCIETY, COLOUR GROUP (at the Victoria and Albert Museum, South Kensington, London, S.W.7), at 3.15 p.m.—Annual General Meeting, 3.30 p.m.—Mr. H. L. Gloag and Dr. R. G. Hopkinson: "Colour and Lighting in Buildings".

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. K. E. Harris: "Some Problems of Secondary Surveillance Radar".

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. F. Seligman: "Some Aspects of the Use of Radio-Isotopes".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. Frank Wokes and Mr. John J. Doherty: "The Use of Recovery Experiments in Fluorimetric Assays of B Vitamins in Food"; Dr. J. M. Shewan and Dr. N. R. Jones: "Chemical Changes Occurring during the Spoilage of Chilled Fish and their Relation to Freshness Tests".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. J. E. O. Mayne: "Current Views on How Paint Films Prevent Corrosion".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. A. V. Cleaver: "Artificial Space Satellites".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC OFFICER, Grade 1 (with a university degree of high standard with chemistry as a major subject, or equivalent qualifications, and preferably some research experience) IN THE DEFENCE STANDARDS LABORATORY, Department of Supply, Maribyrnong, Victoria, Australia, to carry out research on explosives, particularly in the fields of initiation and detonation—The Senior Representative (AP.48), Department of Supply, Australia House, Strand, London, W.C.2 (March 29).

SENIOR LECTURER (with a university degree and good industrial and/or teaching experience) IN ELECTRICAL ENGINEERING, to teach electrical engineering measurements and servo-mechanisms to post-Higher National Certificate standard, and to be responsible for organizing laboratories—The Principal, School of Electronics (Ministry of Supply), Radar Research Establishment, Malvern, Worcs (March 29).

PHYSICIST (preferably with an honours degree in physics or mathematics) IN THE NUCLEAR POWER BRANCH at Headquarters in London, to take charge of a small section responsible for the theoretical and economic aspects, and longer term applications of nuclear power, and the physics problems arising therefrom—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. ND/6 (March 30).

LECTURER IN MATHEMATICS—The Principal, Borough Road College, Isleworth (April 2).

LECTURER (with special qualifications in physical chemistry or in inorganic chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Registrar, University College, Singleton Park, Swansea (April 4).

LECTURER (with a good university degree, preferably in electrical engineering, and a special interest in, and experience of, electrical engineering materials, for example, solid and liquid dielectrics, insulation, and magnetic materials) IN ELECTRICAL ENGINEERING—The Registrar, The University, Birmingham 15 (April 6).

DEMONSTRATOR OR ASSISTANT LECTURER (with a good honours degree in physiology, biochemistry or chemistry with subsidiary physiology) IN THE DEPARTMENT OF PHYSIOLOGY—The Registrar, The University, Manchester 13 (April 9).

HEAD (with high academic qualifications, preferably an honours degree in mining, practical mining experience, and teaching experience) OF THE MINING AND GEOLOGY DEPARTMENT—The Principal, Wigan and District Mining and Technical College, Wigan (April 9).

LECTURER IN CHEMICAL ENGINEERING—The Principal, College of Technology, Manchester (April 9).

READER OR SENIOR LECTURER IN VETERINARY ANATOMY at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 12).

ENTOMOLOGIST (with an honours degree in zoology or other suitable qualification) for fundamental and applied research on insect pests of sugar beet—The Secretary, School of Agriculture, Cambridge (April 14).

LECTURER IN BIOCHEMISTRY—The Secretary, The University, Exeter (April 14).

LECTURERS (2) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Liverpool (April 14).

POPULATION ECOLOGIST (with an honours degree in science, preferably with research experience in the problems of insect population ecology) IN THE DIVISION OF ENTOMOLOGY, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T., Australia, to be one of a group of ecologists working on fundamental field and laboratory studies, under the leadership of Dr. A. J. Nicholson, in particular studying the factors which regulate the abundance of certain forest and orchard pests—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 180/105 (April 14).

RESEARCH METEOROLOGIST (with a university honours degree in meteorology, physics or mathematics, and postgraduate experience of research in synoptic and dynamic meteorology) IN THE DIVISION OF METEOROLOGICAL PHYSICS, Commonwealth Scientific and Industrial Research Organization, Australia, to join a small group working on certain fundamental aspects of dynamic meteorology and the general circulation, and on intensified studies of some local synoptic problems, for example, the cold front of S.E. Australia—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 420/94 (April 14).

LECTURER (with special qualifications in physical and/or inorganic chemistry) IN CHEMISTRY, in St. Salvator's College—Joint Clerk to the University Court, The University, College Gate, St. Andrews (April 15).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Manchester (April 16).

UNIVERSITY DEMONSTRATOR (with a broad scientific education, and experience in some branch of chemical engineering, mechanical engineering or physics) IN CHEMICAL ENGINEERING—The Secretary of the Appointments Committee, Department of Chemical Engineering, The University, Tennis Court Road, Cambridge (April 17).

LECTURER IN MATHEMATICS in St. Salvator's College—Joint Clerk to the University Court, The University, College Gate, St. Andrews (April 21).

ASSISTANT IN PHYSIOLOGY—The Secretary of University Court, The University, Glasgow (April 30).

LECTURER IN PHYSIOLOGY—The Secretary of University Court, The University, Glasgow (April 30).

LECTURER OR ASSISTANT LECTURER IN CLINICAL PARASITOLOGY in the Veterinary School—The Registrar and Secretary, The University, Bristol (April 30).

LECTURER (preferably with a medical qualification, and some experience in teaching and research) IN PHARMACOLOGY, at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, April 30).

LECTURERS (2) (with good academic qualifications and practical experience) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Bristol 8 (April 30).

PROFESSOR OF NUCLEAR PHYSICS and DIRECTOR OF THE NUCLEAR PHYSICS RESEARCH UNIT, at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, April 30).

UNIVERSITY STUDENTS AND FELLOWS for research in experimental or theoretical nuclear physics—The Professor of Natural Philosophy, The University, Glasgow (April 30).

GEOLOGIST (with a degree or equivalent in geology, and a satisfactory knowledge of (*a*) petrology and mineralogy or (*b*) the geology and mapping of glacial and other unconsolidated deposits, or (*c*) stratigraphy and palæontology) IN THE IRISH GEOLOGICAL SURVEY—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (May 17).

ASSISTANT LECTURER and a LECTURER IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Liverpool (May 23).

ASSOCIATED ELECTRICAL INDUSTRIES FELLOWS (2), ONE IN THE DEPARTMENT OF PHYSICS AND ONE IN THE DEPARTMENT OF ENGINEERING—The Secretary-General of the Faculties, University of Cambridge, The Old Schools, Cambridge (May 31).

ASSISTANT, Grade B (preferably with an honours degree, and with either teaching, research or industrial experience) IN PHYSICS—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

CHEMIST (with a first- or second-class honours degree in chemistry and at least two years research experience, either postgraduate or in industry), to undertake original research on the chemical constitution of coal and the basic chemistry of its use, in co-operation with a team of workers at present engaged in studying these problems—The Assistant Secretary, Ref. C.16, British Coal Utilization Research Organization, Randalls Road, Leatherhead, Surrey.

DEPARTMENTAL DEMONSTRATOR IN ENGINEERING SCIENCE for duties which will include both lecturing and undergraduate instruction in the laboratories—Prof. A. Thom, Department of Engineering Science, 19 Parks Road, Oxford.

LABORATORY TECHNICIAN (with bacteriological or virological experience) FOR VIRUS RESEARCH—The Medical Superintendent, Harvard Hospital, Salisbury, Wilts.

MASTER TO TEACH MATHEMATICS—The Head Master, Cheltenham Grammar School, Cheltenham.

PHYSICAL CHEMIST (with at least a first- or second-class honours degree in chemistry or chemical engineering, and many years experience), to lead a team consisting of chemists, chemical engineers and engineers carrying out development in a new field of inorganic materials technology—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1068/34.

PHYSICISTS (Scientific Officer, Experimental Officer or Assistant Experimental Officer grade), at Ministry of Supply Research and Development Establishments, near Farnborough, Hants; Malvern, Worcs; Salisbury, Wilts; and Sevenoaks, Kent, for work on guided missiles, aircraft and aircraft equipment, gas turbines, instrumentation or electronic devices—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.77/6A/BN.

PRINCIPAL SCIENTIFIC OFFICER (Fuel Technology and Chemical Engineering) (with at least a second-class honours university degree or equivalent professional qualifications, and experience in chemical engineering and fuel technology), with the East African Industrial Research Organization, Nairobi, Kenya, to undertake research and development in industrial technology, including processing of crop products, and to study fuel economy in various industries, and generally provide technical assistance to these—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/463/02.

RESEARCH FELLOW (with a good honours degree or equivalent and some specialized experience of paint and/or building materials, and preferably some research experience) to investigate problems of use and behaviour of paint on buildings in tropical climates—Colonial Office, Research Department (S.608), Sanctuary Buildings, Great Smith Street, London, S.W.1.

SCIENTIFIC OFFICERS (with a first- or second-class honours degree or equivalent in electrical engineering, physics or mathematics) AT THE NATIONAL PHYSICAL LABORATORY, Teddington, Middlesex, for work on control mechanisms and electronics, principally the development of digital computers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.90/6A.

SCIENTIFIC/SENIOR SCIENTIFIC OFFICER (with an honours degree in engineering or physics, and preferably with experience of research and experimental work), at a Ministry of Fuel and Power peat experimental station near Falkirk, Stirlingshire, for work on mechanical winning, pressure dewatering and drying of peat for use in power stations—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.956/5A.

SENIOR ASSISTANT (Scientific) (with a knowledge of pulse techniques, high speed oscillography and methods of measuring small time intervals) AT THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, Aldermaston, for development of electronic timing and control equipment for routine testing of explosive items—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. A.551/34.

SENIOR SCIENTIFIC OR SCIENTIFIC OFFICERS (with a first- or second-class honours degree or equivalent in mathematics, physics or engineering) at the Ministry of Supply London Headquarters, for co-ordination of aerodynamic research at research establishments, and of research projects at aircraft firms—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.78/6A/BN.

TECHNICAL OFFICER (with a degree in botany or agriculture or equivalent qualifications and a knowledge of herbage strains, and preferably some practical experience in seed production) IN THE HERBAGE SECTION of the Seed Production Branch—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

A Critical Study of Electrical Stunning and the Jewish Method of Slaughter (Shechita). By Rabbi Solomon David Sassoon. Third edition. Pp. v+48+2 plates. (Letchworth: Rabbi Solomon David Sassoon, 1955.) 2*s.* 6*d.* [181

Dunlop Research. Pp. vi+78. (London: Dunlop Rubber Co., Ltd., 1955.) [181

Wiggin Nickel Alloys No. 37: 50 Years of Monel. Pp. 18. (London: Henry Wiggin and Co., Ltd., 1955.) [181

Macaulay Institute for Soil Research. Collected Papers, Vol. 4: 1951–1954. Pp. 16+70 Papers. (Craigiebuckler: Macaulay Institute for Soil Research, 1955.) [181

Northampton Polytechnic. Report of the Governing Body for the year 1954–55. Pp. 20. (London: Northampton Polytechnic, 1955.) [181

The Baker Interference Microscope. Second edition. Pp. vi+39+9 plates. (London: C. Baker of Holborn, Ltd., 1955.) [181

Library Association. Students' Handbook, 1956. Pp. 277. (London: Library Association, 1956.) 3*s.* 6*d.* [181

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 18, No. 7: Production and a Pelagic Fishery. By D. H. Cushing. Pp. vi+104+2 plates. (London: H.M. Stationery Office, 1955.) 12*s.* 6*d.* net. [181

West of Scotland Agricultural College. Advisory Leaflet No. 44: Seed Mixtures for Hill Farms. By I. V. Hunt. Pp. 4. (Glasgow: West of Scotland Agricultural College, 1955.) [181

Bulletin of the British Museum (Natural History). Zoology. Vol. 3, No. 5: The Monk Seals (Genus *Monachus*). By Judith E. King. Pp. 201–256+plates 3–8. (London: British Museum (Natural History), 1956.) 18*s.* [181

Other Countries

Svenska Linné-Sällskapets Årsskrift, Argång 37–38. 1954–1955. Pp. 192. (Uppsala: Almqvist and Wiksells Boktryckeri AB, 1955.) [181

Reports of the Great Barrier Reef Committee. Vol. 6, Part 2: A Survey of the Distribution of Reef Coral Genera in the Great Barrier Reef Region. By John W. Wells. Pp. 9. (Brisbane: Government Printer.) [181

Atvinnudeild Háskólans—Fiskideild. (The University Research Institute: Department of Fisheries.) Rit Fiskideildar, 2 Bindi, Nr. 2: Temperature Variations in the North Icelandic Coastal Area. By Unnsteinn Stefánsson. Pp. 27. Fjölrit Fiskideildar. Nr. 3: Rannsóknir á Fituinnihaldi Sunnansíldar. Eftir Hermann Einarsson og Unnsteinn Stefánsson. Pp. 1+8. Nr. 4: Yfirbordshiti Sjávar við Strendur Islands Árin 1949–1953. (Surface Temperature in Icelandic Coastal Waters during 1949–1953.) Eftir Unnsteinn Stefánsson. Pp. 1+29. Nr. 5: Síldarrannsóknir "Aegis" Sumarid 1954. (Herring investigations with the Research vessel "Aegir" in the summer 1954. Eftir Jón Jónsson og Unnsteinn Stefánsson. Pp. i+34. (Reykjavik: Atvinnudeild Háskolans—Fiskideild, 1953–1955.) [181

National Institute of Genetics, Japan. Annual Report, No. 3 (1954). Pp. iv+90. (Misima, Sizuoka-ken: National Institute of Genetics, 1955.) [181

Federation of Nigeria. Annual Report on the Geological Survey Department for the year 1953–54. Pp. v+25. (Lagos: Government Printer; London: Crown Agents for Oversea Governments and Administrations, 1955.) 9*d.* [181

Tenth Annual Report of the Council of the Queensland Institute of Medical Research, year ended 30th June, 1955. Pp. 15. (Brisbane: Government Printer, 1955.) [181

Publications de l'Institut National Turc de Bibliographie. Bibliographie des Articles Parus dans les Périodiques Turcs. Octobre–Decembre, 1953. Pp. 163. (Istanbul: Maarif Basimrvi, 1955.) [181

Det Kongelige Industri-, Handverk- og Skipsfartsdepartement: Norsk Polarinstitutt. Skrifter Nr. 104: Tidal Observations in the Arctic, 1946–52. By Helge Hornbaek. Pp. 17. 2,50 kronor. Skrifter Nr. 105: Die Arktische Trichinose und ihr Verbreitungsweg. Von Otto Hornbaek und Hans Walter Schmidt. Pp. 34. 4 kronor. Skrifter Nr. 106: Cambrian and Ordovician Fossils from Sørkapp Land, Spitsbergen. By Harald Major and Thore S. Winsnes. Pp. 47+3 plates. 4 kronor. Skrifter Nr. 107: Stratigraphy of the Marine Late Pleistocene of Billefjorden, Vestspitsbergen. By Rolf W. Feyling-Hanssen. Pp. 186+27 plates. 22 kronor. (Oslo: Brøggers Boktrykkeris Forlag, 1954 and 1955.) [181

International Scientific Radio Union. Proceedings of the 11th General Assembly held in the Hague from August 23rd, to September 2nd, 1954. Vol. 10, Part 6: Commission 6 on Radio Waves and Circuits. Pp. 140. (Brussels: International Scientific Radio Union, 1955.) 150 Belgian francs; 21*s.* 6*d.*; 3 dollars. [181

United States Observatory. Circular No. 63: Positions, Areas, and Counts of Sunspots, September, 1955. By Winifred Sawtell Cameron. Pp. 4. (Washington, D.C.: United States Naval Observatory, 1955.) [181

Memoirs of the Indian Meteorological Department. Vol. 30, Part 3: A Study of Fifty Years' Rainfall of Mangalore. By K. P. Ramakrishnan and J. Narayanan. Pp. 101–153+plates 1–3. (Delhi: Manager of Publications, 1955.) Rs. 6/13/–; 11*s.* [181

East Africa High Commission. East African Virus Research Institute Report, January 1954–June 1955. Pp. i+28. (Nairobi: Government Printer, 1955.) [181

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MACMILLAN & CO., LTD.,
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Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

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